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PHYSICIANS IN CANADA: A CAUSAL ANALYSIS OF STRUCTURE AND CHANGE IN DISTRIBUTION

by

VIJAYA KRISHNAN ©

A THESIS
SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH
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OF DOCTOR OF PHILOSOPHY
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....
Supervisor

....

Trovato..........................

....

J. Stafford..........................
External Examiner

Date 25 April 1989

To my mother

ABSTRACT

One aspect of the so-called "medical crisis" in Canada is the maldistribution of physicians. The probability of physician increase is believed to be greater in wealthier and densely populated areas. If so, effective policies for dealing with the problem of maldistribution depend on our ability to identify and understand the reasons for it. This thesis is directed towards this issue.

In this thesis, a human ecological framework is used to examine the consequences of demographic, socio-economic, ecological, and environmental/ technological factors on the distribution of three groups of physicians: interns and residents, general (family) practitioners, and specialists. The following hypotheses are tested:

1. Population size, age composition, native population, education, owner-occupied dwellings, and geographic proximity influence physician distribution directly and through their impact on hospital beds.
2. Changes in these factors lead to a change in the allocation of hospital beds, which, in turn leads to a change in physician distribution.

In addition, the reciprocal causal effects of physician groups on each other is hypothesized:

3. The reciprocal effects of physician groups occur within the context of a complex process, in which demographic, socio-economic, ecological, and environmental/technological factors all play a part.

The hypotheses are tested on data for physicians from Sales Management Systems (SMS) for census divisions for the years 1971 and 1981 and using bivariate analyses, regressions, and structural modelling (LISREL VI).

A major finding from the analyses is that demographic factors have lessened in predictive power over time. The causal processes vary across physician groups and across time. In a single instance - the case of specialists - the results indicate direct significant effect from hospital beds; an increase in hospital beds leads to an increase in specialists.

Interdependency among physician groups identified in this study suggest that physicians avoid areas which isolate them from collegial network. If this is so, the exorbitant expenditure for the education of more and more physicians just to ensure a minimum supply in "under-serviced areas" will not produce the desired distributional benefit. This points to the need to reassess policies before the cost of growing numbers of

physicians makes an impact upon the society.

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CHAPTER 1

INTRODUCTION

1.1 The Problem

In the past three decades, Canadian health policy has been characterized by the implementation of two major components of its national and universal health care system, namely the Hospital (1958) and Medical Care (1968) Insurance Acts. Supporters of the system boast that it is the best health care system in the world (see Bennett and Krasny, 1981:40). By international standards, Canada's health system provides excellent quality of care and Canadians are reasonably healthy. Yet today, the system is experiencing difficulties on many fronts: unequal access to care, rising cost of health care, excessive hospitalization, maldistribution of health manpower, and lack of public control, all beset both providers and consumers of health (Grafftey, 1972; Bennett and Krasny, 1981).

Over the past two decades, and particularly in recent years, the major focus of discussion has been the cost of health care. A series of reports and studies have emerged echoing essentially the same theme: the cost of health care is growing "out of control" and tough measures are needed if quality of care is to be preserved. As Bennett and Krasny (1977:5) have described: "Canada has been experiencing ever-diminishing health returns from the increasingly large sums of money that have been invested in health care delivery".

The geographical distribution of physicians to ensure equal access to medical care to all citizens is a significant issue that has not been given much attention. In relation to population, it is highly uneven in Canada. As such it requires the intervention of public policy. Though most professions are characterterized by a nonuniform distribution, such a situation is especially undesirable in the case of medical practitioners. Therefore, some knowledge of general trends in the distribution and the factors causing it should be of value.

The number of active civilian physicians in Canada, including interns and residents increased 38 % from 1971 to 1981, far ahead of the 13 % growth in population during the same period. (Statistics Canada, 1985:94). The result was a change from 659 persons per physician in 1971 to 538 persons per physician at the end of 1981 (Table 1.1-1). Despite such unprecedented growth in the number of

Table 1.1-1

Population per Active Civilian Physician[1]: Canada, and Provinces, 1971-1981

Province/Territory	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
Newfoundland	1101	1060	892	828	758	719	700	697	687	655	640
Prince Edward Island	1145	1082	1091	1023	983	853	858	827	801	806	794
Nova Scotia	733	699	622	619	595	593	566	546	537	534	532
New Brunswick	1048	981	962	910	909	883	881	880	906	886	857
Quebec	639	627	601	581	573	557	545	545	531	528	511
Ontario	621	589	583	575	544	545	536	529	524	516	509
Manitoba	645	631	627	620	588	579	569	559	557	545	539
Saskatchewan	813	795	759	721	702	707	677	675	668	669	662
Alberta	690	686	677	660	663	647	649	641	651	648	641
British Columbia	614	592	587	583	568	556	540	532	526	516	514
Yukon	1129	1263	1139	917	948	986	876	804	841	811	850
Northwest Territories	1304	1248	1359	1230	1410	1306	1300	1088	1214	1130	1107
CANADA	659	636	619	605	585	577	566	560	554	547	538
Gini Concentration Ratio	0.067	0.046	0.041	0.035	0.053	0.040	0.039	0.038	0.041	0.042	0.041

---

[1] Total physician count includes interns and residents

Source: Health and Welfare Canada, 1983. Canada Health Manpower Inventory. (Ottawa: Policy, Planning and Information Branch, Information System Directorate).

physicians, little progress towards uniformity in the distribution has been made. The number of persons per physician including interns and residents ranges across provinces from 1107 in the Northwest Territories to 509 in Ontario (Table 1.1-1).

The trend in the distribution of physicians relative to the distribution of population may be assessed by the use of Gini Concentration ratios (indices of centralization) presented in the final row of Table 1.1-1. The ratios are computed using the formula (Brown, 1974):

$$C = 1 - \sum_{i=1}^{k} (Y_{i+1} - Y_i)(X_i + X_{i+1}) \qquad (1.1\text{-}1)$$

where Y is the cumulated proportion of the population over k population size categories, and X is the cumulated proportion of physicians over the k population size categories. The index varies between -1.0 and 1.0 with negative values indicating a tendency for physicians to be concentrated in smaller places and positive values indicating relative concentration in larger places. As Table 1.1-1 indicates, physicians are centralized throughout the period (0.067 in 1971 to 0.041 in 1981); they are less centralized in 1981 than in 1971.

There is also considerable variation in the distribution of physicians within individual provinces, between urban and rural areas, or between one locality and another (Northcott, 1980). While additional physicians increase the cost of health care, there is no evidence to indicate that an increased supply of physicians would contribute to a reduction in the disparity of placement. The rapid trend toward urbanization of society in conjunction with a high degree of specialization among recent medical graduates have created a situation where remote areas remain "underserved" despite the increase in the number of physicians.

The distribution of physicians, assessed on the basis of population-physician ratios does not provide sufficient information on which to base a national policy of health manpower distribution. The method, although could identify some regions as 'shortage area- s', it may not provide much help with policy formulation. Many factors may explain the distribution better than physician-population ratios. In other words, a variety of factors might cause some regions or populations to have more physicians than others. If this is so, then programs designed to improve the distribution must focus on its causes. The objective of this dissertation is to examine and attempt to explain the possible role of four sets of factors in observed differences in physician distribution across census divisions: (1) population, (2) socio-economic, (3) ecological, and (4) environmental/technological.

The central questions attempted are: First, to what extent and in what manner do variables such as population size and available hospital beds influence the distribution of physicians? Do traditional demographic and socio-economic variables explain more or less variance in physician distribution in 1981 than 1971? Second, are the observed changes in physician distribution over the period 1971-1981 accounted for by changes in demographic, socio-economic, and environmental/technological factors? And finally, to what extent do functional dependencies exist among various categories of physicians?

In spite of the growing concern with the uneven distribution of physicians, there are very few - if any - efforts to assess the distribution of physicians in Canada, and to explain why physicians are found where they are. Although substantial variations in ratios of population-physician among the different regions are known, their relationship with factors affecting distribution have not been attempted. Research on the spatial distribution of physicians has been pursued mainly in the United States. This literature has contributed in some measure to an understanding of the factors affecting physician distribution (e.g.,Marden, 1966; Reskin and Campbell, 1974). Little research has been conducted, however, that provides a thorough understanding of how population and environmental/technological factors determine changes in spatial distribution of physicians, to move from cross-sectional analysis to dynamic analysis (Rushing and Wade, 1973; Schwartz et al. 1980).

Although the analysis of cross-sectional data is valuable in understanding the relationship between the variables and physician distribution, its capacity to make inferences concerning the impact of demographic and ecological processes is limited. It is the intent of this study to explain, by using aggregate data for two census years 1971 and 1981, some aspects of intercensal changes in the distribution and to examine these changes within the context of selected characteristics of areas.

There exists little or no research investigating reciprocal causal influences of various groups of physicians. However, there are both theoretical and empirical grounds for adopting such an approach (Anderson 1973; Anderson and Marshall, 1974; Reskin and Campbell, 1974). In brief, evidence indicates the appropriateness of reciprocal causal structure and leads to one of the most important theses of this study, namely, that specialists are influenced by general(family) practitioners, but also exert a causal influence on general(family) practitioners. This perspective represents a substantial departure from the existing unidirectional structure of causal models on physician distribution.

Most studies on physician distribution have applied multiple regression techniques to analyze a variety of factors associated with physician distribution. Some researchers have gone further in modelling the distribution through path analytic approaches. Substantive insights into the process of physician distribution and methodological developments have suggested alternatives to traditional methods of analysis. Recognising measurement errors in observation of variables, the study employs LISREL VI (Jöreskog and Sörbom, 1986), a program that provides maximum likelihood estimates of the unknown parameters in path models containing latent and observed variables, in addition to multiple regression analyses. Since some of the factors are expected to operate differently on various categories of physicians, the analysis will be carried out separately for the three categories of physicians: interns and residents; general(family) practitioners; and specialists. Causal models are developed linking distribution of physicians and demographic and ecological characteristics of the areas served by the physicians. The models make explicit the interrelationships among these variables and the manner in which these variables may directly and indirectly affect physician distribution.

1.2 Defining Distribution

To date, defining distribution has involved designating geographic areas or specific populations as "underserved areas", or "underserved populations" or "shortage areas" on the basis of physician-population ratios. The criteria used to define a 'target' physician-population ratio vary. Two frequently used approaches are the following:

1. A committee consisting of experts in health manpower planning deliberates, reviews data, and then sets a figure (Roos et al. 1976). Thus, when the requirements committee of the physician manpower planning committee submitted its final report in April 1976, it included recommendations for optimal 1981 physician requirements based on the reports of 32 working parties representing the medical specialties across Canada. The requirements committee suggested an overall physician-population ratio of 1:665. In June 1977, the federal/provincial advisory committee on health manpower planning accepted this ratio as its 'target' ratio.

2. A figure which is believed as an ideal one is chosen (Roos, et al. 1976). For example, the ratio for the province of British Columbia is chosen as a 'target' ratio for Canada as a whole.

Ratios are of some value in identifying inequalities in distribution, but they do not constitute an adequate measure of quantity or quality of health care received by the population (a more detailed discussion of the limitations of the ratio approach in manpower planning is considered in section 3.1). More importantly, physician-population ratios do not accurately measure physician availability for residents of a particular area because of frequent boundary crossing for medical care (Makuc et al. 1983). Thus, use of simple ratios by itself may overstate physician supply for some areas and understate it for others. This questions the appropriateness of designating areas as 'shortage', 'under-doctored' or 'over-doctored' on the basis of ratios without reference to needs in terms of total supply of physicians in a given area. As Joseph and Phillips (1984) have noted physician location studies, however, focus on relative disparities in supply rather than on absolute numbers of physicians thereby overcoming the problem of defining need. Therefore, references to 'overdoctored' or 'underdoctored' areas are usually phrased in relative, not absolute, terms (Joseph and Phillips, 1984).

Another approach that has been used to define distribution involves a comparison of specialist-population ratios of large pre-paid and more-or-less self-contained medical foundations operating in the United States. It is believed that these foundations arrive at their optimum ratios more or less accurately; they depend on the demands of members to determine the need for additional specialists within the framework of efficient management and service delivery system (Roos et al. 1976). The use of international comparisons of ratios to arrive at goals is, however, problematic, since their distribution patterns exist in an environment that cannot be duplicated in all regions or communities.

It is safer to conclude that there exists no single and satisfactory approach for designating health manpower shortage areas. Also, there exists no clear definition of distribution goals. A variety of factors influence the demand for and supply of physicians' services. Differences among populations or regions with regard to health levels, demographic, socio-economic compositions, and cultural or environmental characteristics of the population or region, affect the amount of health care services purchased and the supply of medical personnel. In addition, various personal and other factors influence physicians' decisions in choosing locations in which to set up practice. The study is restricted to the former set of factors because of their theoretical importance and availability in the data set.

1.3 The Nature of Physician Distribution - The Concern and the Policies

In the 1960s and early 1970s, a Royal Commission and provincial and federal agencies were concerned with the greater demand for medical manpower. While concern about the adequate supply of physicians has diminished over the past decade, concerns about physician surplus and distribution have increased.

Perhaps, one of the first indications of a real concern came from the Director General of Health Manpower, W. S. Hacon. In his address to the Pan American Conference on Health Manpower Planning in September 1973, Dr. Hacon emphasized the need for a national decision on an appropriate physician-population ratio for Canada (Hacon, 1973). Also, in February 1974, in the Conference of Provincial Health Ministers, it was declared that the nation had sufficient number of physicians to restrict any further immigration of foreign medical graduates. Public concern over physician supply and distribution was clearly echoed in the statement by Evans (1975:364):

> "This point cannot be stressed too hard: *there are too many doctors!*. They may be in the wrong places, and doing the wrong things, relative to what the public or planners would prefer, but increasing their number will not help this problem."

Various strategies have been proposed and tried to deal with the problem of uneven distribution of physicians. A frequently suggested measure to improve the distribution is that of increasing the number of physicians, in the hope that competition might push more physicians into the outlying regions. Such a position is found in an editorial of the Financial Post (1974:5), which stated:

> "The aim should be an ample supply of doctors. If this means a surplus, so much the better. The competition might produce better services in the cities, push more doctors into the underlying regions, perhaps even encourage emigration to where medicos are needed instead of draining them from those places."

Financial incentive is a measure widely used to influence physician placement. For example, Newfoundland and Saskatchewan offer bursaries to medical students in return for practice in the province for a specified period of time which is dependent upon the amount of the bursary given. Those students who fail to fullfill their commitment after graduation from medical school, repay the bursary with interest. In Saskatchewan, the period of service required is reduced if they promise to practice in designated areas after graduation. Quebec also started offering bursaries to medical students, but, unlike other provinces, recipients who fail to honor their commitment not only have to repay the bursary with interest but also forgo the right to participate in the Quebec medical care plan.

Ontario offers subsidies to physicians willing to practice in designated areas. Medically "underserviced" communities are expected to supply adequate housing and clinical facilities at reasonable rent; they are also encouraged to construct a modern health care centre in the community. Ontario, especially Northern Ontario, has had some success with programs designed to attract physicians to such areas. Medical centres have been found to serve as an important factor in attracting physicians. However, there are concerns about the capacity of such programs to influence physician distribution, in the long-run. Thus, in their evaluation of programs in Ontario, Bass and Copeman (1975:407) indicate precisely this concern:

> "The Programme for Underserviced Areas (Physicians), in terms of its limited objective (placing more physicians in underserviced areas), has been successful. There has been a positive effect on the distribution of general practitioners in northern Ontario but, over the long-run, physician maldistribution will require more aggressive and powerful action."

Other programs, much smaller in size, include the provision of salaries to physicians who are willing to practice in remote areas. Thus, Newfoundland offers salaried positions to physicians willing to practice in cottage hospitals and in rural communities.

The belief that an increase in the supply of physicians in itself will lead to a more uniform distribution is inconsistent with trends of the past decade. Although programs designed to redistribute physicians have been successful in some cases, it is unlikely that in the long-run, the rural areas will benefit as long as a highly disproportionate number of physicians choose to practice and live in urban areas. Such areas, for most health professionals would be an economically thriving one with good hospitals, well educated people, and general amenities. It is desirable, therefore, to have more information on the factors underlying the distribution in order to change the disparity.

1.4 Rationale and Scope of the Dissertation

The fundamental concern of human ecology was first stated by Hawley (1944; 1950) and later developed by Duncan and Schnore (1959; Duncan, 1959; 1961; Schnore, 1958; 1961; 1965). According to Hawley (1950:68), the main task of human ecology involves "the study of the form and development of the community"; community structure, from the ecological point of view was conceived as the organization of sustenance activities - the manner in which a population organizes in order to live in a particular habitat. This organization of sustenance activities results in a spatial distribution, which Hawley emphasizes as a useful dimension for the measurement of organization.

Hawley's statement of the objective of human ecology has been shown to be consistent with a long-standing sociological tradition (see Schnore, 1958). In Durkheim's (1933) conception of social morphology, for example, may be found key elements forming a foundation for ecological theory. These are analysis on a macro-level (utilizing an aggregate of individuals as the basic unit), concern with the relationship between the organization of a population and its environment, and the study of the characteristics of a population. These elements, traced by Schnore to Durkheim, have emerged as the central concepts in the formulation of a theoretical frame of reference, known as the "ecological complex", in human ecology (Figure 1.4-1).

The "ecological complex" is a frame of reference which consists of population, organization, environment, and technology - frequently referred to by the acronym

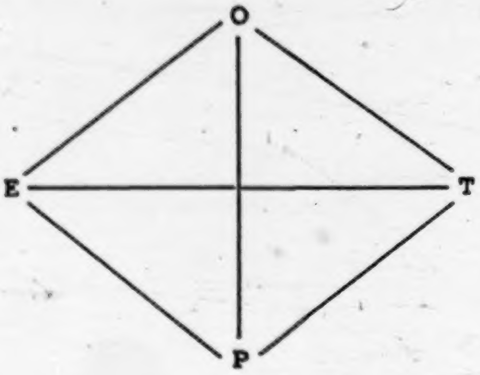


Figure 1.4-1. The Ecological Complex

POET (Schnore, 1958; 1961; Duncan, 1959; 1961; Duncan and Schnore, 1959).[1] In short, the ecological complex identifies the relationship among the four classes of variables, each of which is causally interdependent as each may serve as an independent or a dependent variable. However, in sociological research, organization is often treated as a dependent variable to be explained by the other three independent variables. Thus, if we use organization as a dependent variable, our task is to see how population, environment and/or technology operate in the modification of organization.

In the POET framework, the changing relationships of the four components are a major focus of analysis. An ecological account of changes in social structure may be attempted by referring to such factors as environmental change, changes in size and composition of population, introduction of new technology, and shifts in the spatial disposition or organization of populations. In other words, the interdependence of factors in the adaptation of a population clearly indicates that change in any one of the factors will result in a change in any other factor (The lines forming the vertices in the ecological complex are meant to suggest the idea of "functional interdependence").

The analysis of institutional distribution is one of the issues in the study of community structure. If institutions can be thought of as "agencies established for the services of the needs of the population" (Hawley, 1941:631), any population must face the need to maintain an adequate supply of institutions. The supply is thought to be determined by a nation's/community's population, environment, and technology. If health facilities and services are regarded as a type of institution, undoubtedly, the availability of such facilities in a particular community will depend to a larger extent on other characteristics of the community.

It is hoped that this study, which is based on ecological perspective and specifically the POET scheme, will provide a useful framework for studying the factors influencing physicians at any given time and for predictions of changes in distribution over time. The causal approach adopted in the study is hoped to provide a major insight into the demographic and ecological processes that affect the distribution of physicians. Also, it is hoped the model will permit predictions of future demands on the health care system resulting from changes in the factors associated with the distribution.

1.5 Limitations of the Study

It is necessary to acknowledge some limitations of the study. First, the time period covered in the study is from 1971 to 1981. This is a rather short period, but its choice is dictated by the fact that adequate and comparable data on physicians coded to census divisions are available only for these two years, although adequate time series data on other variables exist for other years.

A second major limitation of the study lies in the choice of census divisions as the basic unit of analysis. It is recognized that the census divisions are only approximations of the most appropriate unit of analysis, the medical service area. The concept of a medical service area is very difficult to operationalize mainly because it is not always congruent with boundaries relating to other relevant sources of data. The use of the census divisions - the geo-political units - however, makes it possible to examine the relationships between physician distribution and other demographic and ecological data, since both data are available for census divisions. A further advantage is that census divisions are comparatively stable geographic units; census division boundaries change little over time.

In the United States and to some extent in Canada and Australia, macro-scale studies of physician undersupply have been identified repeatedly as a major rural problem (Reilly et al. 1980; Phillips and Williams, 1984).

As yet, however,there is relatively little work which examines locational patterns within rural areas, probably due to the paucity of comprehensive data on physicians by rural-urban breakdown. Physical distance and poor transport availability can be very real obstacles both for providers and users of health care in rural areas. Mosely (1979) has argued that even in many developed countries, accessibility to services and facilities remains the 'rural challenge'. It is necessary to acknowledge that this study is deficient in this important respect; it fails to examine rural-urban disparity in physician distribution. It has been evident, however, that potential physical accessibility can be viewed as a function of physical proximity to large institutions (Joseph and Phillips, 1984:144). That is, locally based health care facilities could give rise to improvements in the geographical accessibility of care, in that the average distance between facilities and potential clients will be reduced. Thus, because data were not available on the rural-urban supply of physicians in this study, resort was made to a less satisfactory but practical alternative, a locational variable (that is, distance to large urban centres). Given the complexity of factors influencing physician supply, the identification of the specific role of this variable, is clearly a challenging task.

In this connection it should also be mentioned that the inclusion of population size will increase the possibilities for measuring urban-rural influences. There is no empirical evidence to support the contention that the most populous (urban) areas tend to have above-average physician-population ratios. There is also no evidence indicating that when population size and a dummy variable for region (urban/rural) are both included among the independent variables multicollinearity will result. It is expected that population size and distance (to larger urban centres) will primarily tap the variation in physician/population ratios. Given the enormous difficulties of accurately discriminating between urban and rural areas (Roos et al. 1976) defined an urban area as one with a population of over 5,000 and with more than 50 beds in 1971. (This is somewhat crude.) We equated population size and geographic proximity with urban/rural dummy (see Frisbie and Poston, 1975). Hence, while it is expected that urban/rural variable be closely related to physician/population ratios, it is also expected that population size and geographic proximity serve as surrogate measures and will be more strongly related to physician/population ratios at the census division level.

One final limitation - perhaps not very serious - that should be made explicit concerns the use of aggregate level data. The variables in the study are treated as macro-level variables rather than as properties or characteristics of individuals. An important drawback with such an analysis is that relationships at this level of observation may not apply to associations among other analytic units such as census tracts or to the behaviour of individuals (Robinson, 1950). Because of this possibility, research findings for census division characteristics should not be imputed to individual units of observation.

However, even with these limitations, it is hoped that a good deal of knowledge can be obtained about the nature, causes, and causes of change in physician distribution in the country.

1.6 Outline of the Dissertation

The remainder of the dissertation is presented in the succeeding seven chapters. Chapter 2 deals with an overview of medical care services in Canada and the provinces. In chapter 3, a review of past studies and literature on physician distribution is presented. A discussion of the methodology is given in Chapter 4. In particular, the dependent and independent variables to be used in the analysis are defined operationally in Chapter 4. Also a brief description of LISREL (Linear Structural Relations), a statistical procedure for estimating the model parameters is presented. In chapter 5, the data are analyzed using bivariate and multivariate analyses (stepwise regressions) for the two years and the nature of relationships between the variables is discussed. In the latter part of chapter 5, the nature of relationships observed for each of the three categories of physicians -- interns and residents; general(family) practitioners; and specialists -- are compared for the two time points. In chapter 6, the results of analyses of structural equation models are discussed seperately for the two time points followed by specification of structural and measurement components of models. In Chapter 7, change in physician distribution over the period 1971-81 is examined with discussion of both multiple regression analysis and structural equation analysis. Chapter 8 provides a summary of the dissertation with conclusions, implications and suggestions for future research.

CHAPTER 2

AN OVERVIEW OF THE CANADIAN HEALTH CARE SYSTEM

The health care system in Canada has been in a major transition for the past few decades. The transition was from a mainly private responsibility administered and supported by private charities or religious organizations, to an increasingly comprehensive public responsibility. From the individual's point of view, the present health programmes protect him from crippling medical or hospital bills. But, the removal of individual responsibility for payment along with an increase in scientific insight and technological advances in medicine has resulted in greater demand for care which Canada's health system has been unable to meet completely. There is currently much dispute over whether inequalities actually exist. There is, of course, indeed considerable evidence to suggest that occupational differences and, in general, social class differences do exist. For instance, persistant differences in mortality between natives and the general population is an important aspect of inequality. As mentioned earlier, there are concerns about costs and equal access: socially, geographically, and financially.

This chapter is intended to provide perspective on the health care delivery systems operating across provinces in Canada. Many books and countless articles have traced the development of the Canadian health care system and its organization. This chapter provides a selective overview, drawing on many works, and in particular the works of Andreopoulos (1975), Hastings (1971, 1972), and Bennett and Krasny (1977; 1981), Meilicke and Storch (1980), Evans (1984), Lomas et al. (1985), Statistics Canada (1985; 1988), and Coburn et al. (1987). While certainly not complete, it attempts to give some glimpses of the history and development of the health service system, and, in particular, to portray the growth of the universal Federal-Provincial Hospital Insurance Plan and the Medical Care Insurance Program. In addition, some of the issues and problems facing the health care system are discussed with emphasis on the financing and cost of the health services, manpower and facilities, and planning and organization of health services.

Before turning to the major theme of this chapter, it may be helpful to examine briefly the geographic and demographic nature of the country. Additionally, the health status of Canadians which has relevance for the health service patterns noted in this country is also examined.

2.1 The Health Status of Canadians

Canada, a huge country with a land area of 10.1 million square kilometers is larger than Europe or the United States but has only about one-twentieth of the population of Europe and about one-tenth of that of the United States as of mid-1985. The country has a population of 25.4 million, about 10% of which is comprised of persons 65 years or older. Although Canada has many small communities, the greater part of the population (76%) is urban, and about 25% of the population live in the three metropolitan areas of Montreal, Toronto, and Vancouver. The long-term trend is toward an increasing urbanization and it is projected to grow from 76% to 90% by the year 2000; thus, 90% of the country's population will live in cities or large towns.

The country is comprised of ten provinces and two territories, each having a very uneven distribution of people and natural resources. Prince Edward Island is the smallest province with a population of 125,000, while Ontario is the largest with a population of 9.1 million in 1986. The provinces fall into five natural groups: the Atlantic Provinces (Newfoundland, Prince Edward Island, Nova Scotia, and New Brunswick), Quebec, Ontario, the Prairies (Manitoba, Saskatchewan, and Alberta), and British Columbia. Quebec and Ontario stand alone because of their large area and population, while British Columbia is isolated from the rest of Canada geographically by the Rocky Mountains.

Canada was formed in 1867 by the union of four seperate British Colonies. The constitution makes it a confederation with federal responsibilities for international affairs, defence, native people, and transportation (railways). The Canadian health care delivery system is based on federally subsidized hospitalization and health care programmes. The programmes are administered by the ten provinces under the general supervision of the Department of the National Health and Welfare. Formerly, under a 50-50 cost-sharing arrangement, federal contribution to health care amounted to the same as provincial health expenditures. The cost-sharing agreement, however, was replaced in 1977 with the Established Programmes Fiscal Arrangements Act (EPF) by a transfer of tax-points and block funding geared to the growth in GNP. Thus, the money with which the provinces can fund health care will be tied to their tax revenues and the growth of Canada's GNP (Hall, 1980). In the Northwest Territories and the Yukon, the health services are directly administered by the federal government. Also, two sections of the Canadian population rely directly on the federal government for all or part of their health care: the Indians, and ex-servicemen and their families.

Canadians appear to be reasonably healthy compared to people in other developed countries. Table 2.1-1 shows how Canada compares with ten other developed countries in terms of infant mortality per 1000 live births and life expectancy at birth for males and females. In 1985, Canada had the seventh lowest infant mortality rate (8.1) among the 11 countries considered. In life expectancy at birth, Canada has one of the highest average life expectancies of any nation, for both males and females; Canadian men rank third (73.0 years) while Canadian women rank first (80.1 years). A major reason for high life expectancy at birth is the drop in infant mortality; death rates for infants under one year of age declined about 76% between 1951 and 1981 (Statistics Canada, 1985:85).

The relative supply of physicians and the availability of hospital facilities are commonly held to be principal factors responsible for the higher levels of health status. Table 2.1-2 provides the information on physicians, nurses and midwives, and hospital beds per 10,000 population. Canada's position in 1977 (more recent data for international comparisons are not yet available) was relatively favourable regarding physicians with a supply of 17.8 physicians per 10,000 population and with a corresponding rank of fourth among the 11 countries

Table 2.1-1

Infant Mortality Rate per 1,000 Live Births and Life Expectancy at Birth: Canada and Eleven Industrialized Countries, 1985

Country	Infant Mortality Rate	Life Expectancy at Birth Male	Life Expectancy at Birth Female
Australia	9.2	72.6	79.1
Canada	8.1	73.0[d]	81.1[d]
Denmark	7.7[d]	71.8[d]	77.8[d]
Finland	6.5[d]	71.8[d]	79.0
France	8.0	71.7[d]	80.1[d]
German Federal Republic	9.6	71.6	78.3
Japan	5.5	75.0	81.0
Netherlands	7.9	73.0[d]	79.9[d]
Sweden	6.7	73.9[d]	80.1[d]
United Kingdom	10.2	71.9	77.9
United States	7.0	71.0[d]	78.3[c]
USSR	27.7[a]	64.0	74.0[b]

[a] 1974 [b] 1971-72 [c] 1983 [d] 1984

Source: World Health Organization. 1986. World Health Statistics Annual: Vital Statistics and Causes of Death. (Geneva: World Health Organization).

Table 2.1-2

Physicians, Nurses and Midwives, and Hospital Beds per 10,000 Population: Canada and Eleven Industrialized Countries, 1976/77

Country	Physicians	Nurses and Midwives	Hospital Beds
Australia	15.37	86.21	124.4
Canada	17.76	77.73	87.0
Denmark	19.52	60.51	87.2
Finland	16.05	96.20	153.1
France	16.32	59.12	105.5
German Federal Republic	20.40	39.40	117.8
Japan	11.83	37.13	106.0
Netherlands	17.16	37.52	100.9
Sweden	17.75	79.35	149.0
United Kingdom	15.17	41.69	83.1[a] (89.6)[b]
United States	16.80	67.40	63.0
USSR	34.64	61.38	121.3

[a] Figure for England

[b] Figure for Wales, 1974

Source: World Health Organization. 1980b. World Health Statistics Annual: Health Personnel and Hospital Establishments. (Geneva: World Health Organization).

considered. Canada ranks fourth with respect to nurses and midwives (77.3), and is in the tenth position with respect to hospital beds (87.0).

Although it may not be directly responsible, the overall expenditures on health care can influence the health status of the people. Recent research shows that there is a strong correlation between the supply of physicians and the medical expenditures in a country (e.g., Rushing and Wade, 1985). Canada, in 1975, spent 7.5% of its gross national product on health care (Table 2.1-3). It ranks sixth in this regard amongst the developed countries considered.

Across Canada, the variations in infant mortality rates or life expectancy at birth by province (Table 2.1-4) are not as great as might be expected, considering the variation in physician-population ratios, nurse-population ratios, bed-population ratios (Table 2.1-5), and the expenditure on health care (Table 2.1-6). Newfoundland, Nova Scotia, Quebec, Ontario, Manitoba, Saskatchewan, Alberta and British Columbia had reached the overall goal of physician-population ratio of 1:665 in 1981 (Table 1.1-1), a ratio set for 1981 by the National Physician Requirements Committee established by Health and Welfare Canada. In contrast are Prince Edward Island with a comparatively low ratio of 1:794 and New Brunswick with

Table 2.1-3

Health Care Expenditures as a Percentage of GNP: Canada and Eight Industrialized Countries, 1975

Country	1975
Australia	7.0
Canada	7.5
Finland	6.8
France	8.1
German Federal Republic	9.7
Netherlands	8.6
Sweden	8.7
United Kingdom	5.6
United States	8.4

Source: Simanis J. G. and J. R. Coleman. 1980. Health Care Expenditures in Eight Industrialized Countries, 1960-76. Social Security Bulletin. vol. 43(January):3-8.

Table 2.1-4

Infant Mortality Rate per 1,000 Live Births and Life Expectancy at Birth: Canada and Provinces, 1981

Province or Territory	Infant Mortality Rate	Life Expectancy at Birth	
		Male	Female
Newfoundland	9.7	72.0	78.7
Prince Edward Island	13.2	72.8	80.5
Nova Scotia	11.5	71.0	78.4
New Brunswick	10.9	71.1	79.2
Quebec	8.5	71.1	78.7
Ontario	8.8	72.3	79.0
Manitoba	11.9	72.2	78.8
Saskatchewan	11.8	72.4	79.6
Alberta	10.6	72.0	79.1
British Columbia	10.2	72.6	79.6
Yukon	14.9	65.0	74.5
Northwest Territories	21.5	65.0	74.5
Canada	9.6	71.9	79.0

Source: Statistics Canada. 1981c. Life Tables, Canada and Provinces. (Ottawa: Statistics Canada).

Table 2.1-5

Physicians, Nurses, and Hospital Beds per 10,000 Population: Canada and Provinces, 1981

Province or Territory	Physicians	Nurses	Beds
Newfoundland	15.82	85.45	62.37
Prince Edward Island	12.79	92.97	83.40
Nova Scotia	19.04	97.31	74.79
New Brunswick	11.82	104.15	76.00
Quebec	19.84	88.20	84.57
Ontario	19.95	114.87	64.18
Manitoba	18.84	85.37	79.22
Saskatchewan	15.44	89.11	87.41
Alberta	16.11	90.82	79.00
British Columbia	24.80	120.72	100.20
Yukon	12.13	-	68.91
Northwest Territories	9.22	67.19	95.74
Canada	18.91	99.38	75.13

Note:Hospital beds include general, allied special, and mental

Source: Statistics Canada. 1985. Canada Year Book, 1985. (Ottawa: Statistics Canada).

Table 2.1-6

Total Health Expenditures Public and Private: Canada and Provinces, 1981

Province or Territory	Total Expenditures (Million Dollars)	Per Capita ($)
Newfoundland	516	909
Prince Edward Island	118	959
Nova Scotia	875	1,032
New Brunswick	660	948
Quebec	6,648	1,032
Ontario	8,983	1,041
Manitoba	1,126	1,096
Saskatchewan	984	1,015
Alberta	2,600	1,157
British Columbia	3,185	1,158
Yukon and Northwest Territories	76	1,091
Canada	25,769	1,058

Source: Statistics Canada. 1985. Canada Year Book, 1985. (Ottawa: Statistics Canada).

1:857. Five provinces - Newfoundland, Prince Edward Island, Quebec, Manitoba, and Saskatchewan - have relatively low nurse-population ratios when compared to the national average (Table 2.1-5). Alberta has a relatively high nurse-population ratio (90.8). British Columbia is first with respect to hospital beds (100.2 per 10,000 population) while Saskatchewan is in second place (87.4 per 10,000 population). Total health costs per person in the provinces in 1981 ranged from $1,158 in British Columbia to $909 in Newfoundland (Table 2.1-6). British Columbia and Manitoba ($1,096) are the only other provinces to exceed the $1,058 national average, along with the Territories ($1,091).

A major factor influencing Canada's relatively favourable health status is obviously the nation's health care delivery system. While some observers of the Canadian health scene believe that Canada's system is among the best in the world, it must be admitted at the same time that areal variations in physician availability are wider than what is acceptable to the society. To some extent, these variations have resulted from the already noted fact that physicians prefer to practice in cities. As Coburn et al. (1987: 653) note:

> "Greater inequality in Canadian Society would consequently lower the health and health care for the underprivileged to the level of that in the United States. More

> immediately, ... we can point to examples of relatively neglected issues, such as native health care, the impact of an aging population, occupational health, social-class differentials in health status and in the quality of health care, and the lack of public individual involvment in health care decisions."

While the ratios provide a rough basis for comparison among provinces, one should not completely rely on them and conclude that there is an over(under)-supply of physicians. One reason is that most of Canada's provinces are large in size - some such as Quebec and Ontario have land areas about twice the area of France - so that even a province presents a very heterogeneous picture of health services.

2.2 Background to Today's Health Services Programmes

This section gives a brief overview of health services programmes in Canada with particular emphasize on the two most dramatic events in the health care history; the launching of the national hospital insurance programme in 1958 and the national medical care insurance in 1968. The subsection that follows will look at the history of Canada's health services to the end of World War II. As noted earlier, references to this chapter include many of the important Canadian books and articles: Hastings (1971, 1972), Andreopoulous (1975), Bennett and Krasny (1977; 1981), Meilicke and Storch (1980), Evans (1984), Lomas et al. (1985), Statistics Canada (1985; 1988), and Coburn et al. (1987), to list a few.

2.2.1 Historical Review of Health Services to the End of World War II

Under the terms of the British North America Act of 1867, the Canadian federal government was assigned jurisdiction over quarantine, and the establishment and maintenance of Marine Hospitals while the provinces were assigned jurisdiction over the establishment, maintenance and management of hospitals, charities and charitable institutions in and for the provinces. The provision of health care services, has, therefore, traditionally been acknowledged as the responsibility of the province (LeClair, 1975).

In the beginning, federal health activities were administered by the Department of Agriculture. Later on, they were divided between the Departments of Marines and Fisheries, Agriculture and Inland Revenue. In 1919, the federal Department of Health was established by an Act of Parliament. In 1928, the Department of Health was changed to create the Department of Pensions and National Health by a merging of the former with the Department of Soldiers Civil Reestablishment. A further change was made in 1944 with the creation of Department of National Health and

Welfare. This was followed by the creation of the Department of Veterans Affairs and thus veterans' services were transferred to this department.

Health activities, under the federal Department of National Health and Welfare were divided into three major categories: (1) The federal goverment was assigned the responsibility of mariners' services, quarantine, Indian health services and civil service health; (2) Regulation of the distribution of the sale of food and drugs; and (3) The provincial responsibilities included the control of veneral disease, blindness, child and maternal hygiene, industrial and nutrition services, and public health education.

The first major national governmental thrust to develop a better health care system for Canadians occured in 1945 when the federal government laid before a Dominion-Provincial Conference on Post-War Reconstruction a wide range of proposals (Hastings, 1971). Health Insurance was one of several social security measures proposed at that conference. The federal government proposed to pay to the provinces 60% of the estimated costs of a broad range of health services such as medical, hospital, dental, pharmaceceutical, and nursery benefits. But, the financial offer was conditional on the provinces accepting transfer of important tax fields to the federal government. Federal action on health services was postponed due to failure to agree on the tax transfers.

It was not until 1948 that the federal government decided to implement certain sections of its health programme without reference to agreements in the field of taxation. Thus, in May 1948, Mackenzie King, as Prime Minister of Canada, offered the health grants without the prior condition of health insurance, describing that they are fundamental prerequisities to the development of a comprehensive health insurance plan in Canada (Gelber, 1959).

Planning for post-war reconstruction had been initiated by the Cabinet early in 1942. The Canadian Medical Association, the Canadian Hospital Association, the Canadian Nurses Association and several other groups such as labour, farm and church were joined in support of health insurance. Thus, by the end of World War II, Canada had, almost eighty years after Confederation, reached the stage of considering major steps in an overall programme of social insurance for its people.

At the provincial level, in 1915, Ontario began a programme of workers compensation which subsequently was introduced in all other provinces (Hastings, 1971). According to the programme, workers received cash compensation for a portion of their wages, all necessary medical, hospital, and rehabilitative services, and pension awards when there were permanent work-related accidents and illness. The programme was financed through compulsary graded assessment on employers according to the hazard in each class of industry. Although there were variations across provinces, the programmes apply to almost all occupations and industries (Hastings, 1971).

The municipal doctor plan first established in Saskatchewan in 1917 was adopted in Manitoba in 1921. Saskatchewan took a significant step along the long road to health insurance when it passed the legislation to permit the establishment of municipal hospital care plans to enable municipalities, towns, and villages to co-operate in engaging the services of a physician.

The first provincial involvement in Alberta with health insurance appears to have been in 1919, with the Municipal Hospital Plan, involving the Lethbridge Hospital. It was not until 1926, however, that legislation was passed establishing the municipal doctor plan, as in Saskatchewan.

Between 1935 and 1945 various health insurance bills were passed by the legislators of Alberta, British Columbia, Saskatchewan, and Quebec, but, for a variety of reasons both political and economic, the laws were not implemented (Hastings, 1971). There is no evidence of any specific measures undertaken or proposed for medical care insurance in any of the Maritime provinces prior to the end of World War II.

Newfoundland, then not part of Canada, in 1934 launched a system known as the Cottage Hospitalization and Medical Care Plan (Hastings, 1971). It was primarily designed to assist the fishermen and their families in the outports. Under this programme, doctors were employed on salary to provide personal health care and public health services. The programme presently exists in modified form under the province-wide financial coverage for hospital and medical services.

2.2.2 The Development of Hospital Insurance Programmes

Immediately after World War II, most provinces took serious steps to establish universal insurance schemes. Saskatchewan was the leader and the province passed the Saskatchewan Hospitalization Act in 1946 (LeClair, 1975). This resulted in the implementation in 1947 of a universal compulsory hospital insurance programme covering virtually all residents of that province (LeClair, 1975). Also in 1946, another pioneering programme, the Swift Current Medical Care Plan, was started under which all municipal doctor plans in Health Region Number 1 were integrated into a regional medical care programme, financed through local income taxes and supported by the provincial government (Hastings, 1971; LeClair, 1975).

In 1949, British Columbia followed the lead of Saskatchewan and introduced a province-wide hospital insurance programme (Hastings, 1971). Alberta initiated a less extensive plan based on support from the existing municipal hospitalization plans. Also in 1949, Newfoundland joined the Canadian Confederation and brought its Cottage Hospitalization and Medical Care Plan with it (Hastings, 1971).

At the federal level, the first step was the introduction of a new programme of National Health Grants (LeClair, 1975). They were started in 1948 and were considered as "being fundamental prerequisites of a nation-wide system of health insurance" (Gelber, 1959:256). The programme covered support for a wide range of provincial services, including health planning, public health, hospital construction, professional training, and other services.

By the mid-1950s, province-sponsored hospital insurance plans were in operation in four provinces, in addition to the expanded voluntary hospital insurance programmes. The provinces were finding it hard to raise the necessary revenues to meet the costs of providing hospital services and they urged the federal government for some action in the field (LeClair, 1975). In 1955, the provinces requested (led by Ontario) the federal government to include the subject of health insurance on the agenda of the forthcoming federal-provincial conference (Hastings, 1971). At the conference, the federal government indicated its willingness to provide financial support to provincial hospital insurance plans.

The Hospital Insurance and Diagnostic Services Act came into effect in July 1958 (Statistics Canada, 1988). It was a conditional grant-in-aid, with the federal funds available only to provinces meeting certain conditions. The basic thrust of the programme was to ensure that hospital facilities and services would be available to the public on a universal basis. Further, it provided an equalization of financing across Canada by reimbursing the provinces on a cost-sharing formula basis with half the funds to cover the cost of operating hospitals, including those medical services which were related to diagnosis within hospitals, laboratory and radiology services. The Act provided that no federal contribution would be paid until at least six provinces comprising half the population of the country had entered into agreement with the federal government. On July 1, 1958, five provinces started the programme and by January 1, 1961 the last province, joined the programme (LeClair, 1975).

2.2.3 The Development of Medical Care Insurance

In 1961, the federal government appointed a Royal Commission on Health Services (the Hall Commission) to inquire into and report on the existing facilities and future requirements for the provision of adequate health services, the method of financing such services, and the estimated cost of health services with projected cost for the extension of existing programmes or the implementation of new programmes, and matters that were appropriate for improvement of health services (Hastings, 1971). The Royal Commission recommended a national comprehensive plan for personal health services after carefully conducting a thorough and complete survey of the health situation in Canada (Canada, 1964).

Shortly after the establishment of the Hall Commission, there were several initiatives at the provincial level. In 1962, Saskatchewan introduced an insurance plan to cover medical care services (Stratton, 1979). The medical profession reacted vigorously in opposing the introduction of the bill and the result was a doctors' strike lasting almost a month. Public opinion began to move against the striking physicians and eventually on July 23, the parties signed a document which became known as the Saskatchewan Agreement. In 1963, Alberta initiated its Alberta Medical Plan with the cooperation and support of the medical profession and the voluntary carriers (in particular, the private insurance companies) (Hastings, 1971). British Columbia, in 1965, established a nonprofit plan through the support of the medical profession of the province, for people not enrolled in group plans, with subsidies for low-income persons (Hastings, 1971). Ontario, following Saskatchewan and Alberta began a programme in 1966 providing coverage for people not enrolled in group plans, and subsidized low-income persons (Hastings, 1971).

On July 19, 1965, the federal government convened a conference involving the provinces to discuss federal and provincial actions in establishing and operating programmes that will provide health services to all Canadians on a comprehensive basis (Black et al. 1978). At the meeting, Prime Minister Lester Pearson made his announcement concerning the decision of the federal government to go ahead with the establishment of a national medical care insurance plan. Three years later (July 1, 1968), after discussions and negotiations with the provinces, the federal government brought in its

Medical Care Act. The federal government offered grants of 50% of the national per capita cost to provinces that introduced a medicare programme that met four basic principles:

> "Comprehensiveness - The plan had to provide comprehensive coverage for all medically required services with no dollar limit on any service.
>
> Universality - Access to insured services must not be inhibited by excessive user charges. The plan had to be universally available (meaning on uniform terms and conditions to all residents) and provide coverage to not less than 95 per cent of the population.
>
> Portability - Benefits had to be portable from one province to another, so that persons retained coverage when temporarily absent from the province or during a change of residence to another province.
>
> Public Administration - The plan had to be publicly administered on a non-profit basis."(Stratton, 1979:2)

Thus, Canada, half a century later, brought into effect the national plan of medical care insurance first proposed in 1919. There were only two provinces participating - British Columbia and Saskatchewan - on its effective date; however, other provinces eventually joined the programme.

2.2.4. Other Developments in Health Services

The past two decades have witnessed a number of other developments in the health care field. Some of the more notable ones are presented below.

The Canada Assistance Plan was enacted in 1966 by the federal government as a comprehensive public assistance measure to complement other income security measures (LeClair, 1975). It provides, under agreements with the provinces, 50% of the cost of the public assistance, and certain welfare services including health services.

Another important national development was the establishment of the Health Resources Fund (1966), under which the federal government would pay to the provinces up to 50% on approved projects for planning, acquisition, construction, renovation, and equipping of health training facilities (Hastings, 1971).

In 1970, seven federal task forces on the Cost of Health Services in Canada made recommendations on cost control, which were being studied by the various governments (Hastings, 1971). The reports made by these task forces led to the establishment of an expert committee in June 1971, to make recommendations to the Conference of Canadian Health Ministers in June 1972 on the role of governments in developing various types of recommended community health centres (Hastings, 1971).

In recent years a number of provinces have launched major investigations into their health systems by the provincial health departments or by special committees or commissions. These include: Ontario's Committee on the Healing Arts Report (Ontario, 1970), Quebec's Castonguay Commission Report (Quebec, 1970), Manitoba's White Paper (Manitoba, 1972) Nova Scotia's Council of Health Report (Nova Scotia, 1972a; 1972b), British Columbia's Foulkes Report (British Columbia, 1973), and Ontario's Mustard Report (Ontario, 1974). They focus on ways to improve access to beneficial health services and to reduce the cost of providing these services.

Until 1977, the federal government contributed to the provinces about 50% of approved expenditures for services provided under the hospital and medical insurance plans (Statistics Canada, 1988). With the introduction of Established Programmes Fiscal (EPF) Arrangements Act in 1977, the federal contributions to the provinces were no longer tied to provincial spending but to the average rate of growth in gross national product (provinces need to meet the criteria under federal legislation to be eligible for fundings) (Statistics Canada, 1988). Such contributions were also made to the provinces toward the cost of certain extended health care services, such as nursing home, adult residential, ambulatory and home care services.

Since the new federal-provincial cost-sharing agreement, in many provinces, physicians and surgeons have decided to charge their patients additional sums for consultations. In 1980, the federal government recalled Justice Hall from retirement to conduct a review of the Canadian health insurance system. The Hall review, A Committment for Renewal, arrived at the conclusion that user fees and extra-billing are the major challenges to the original principles of Canadian health insurance system (Coburn et al. 1987). The result of the review led to the development of the Canada Health Act (Canada, 1985). The then minister of health, Monique Begin, after trying for years to prevent provincial governments from allowing their physicians to extra-bill brought in new legislation in 1984. She claimed that the act will redefine universality, comprehensiveness, portability, and accessibility in service provision. Extra-billing and user fees were banned. The Canadian Medical Association (CMA) questioned the constitutionality of the Health Act stating that, "the ultimate goal of this legislation is to radically change Canada's ten diversified provincial health insurance programmes into state medicine - into a medical service that is completely controlled by government" (Canadian Medical Association, 1984:10). The Ontario medical profession, however, failed to prevent the ban on extra-billing despite their longest strike in Canadian history (Coburn et al. 1987).

2.2.5 Policy Approaches to Medical Manpower Planning

A recent study by Lomas and his associates (Lomas et al. 1985) highlights the central issue of this section. More specifically, the section offers a historical review of physician manpower policy development from the introduction of universal health insurance in 1969 to the present day (see Lomas et al. 1985 for a comprehensive discussion).

Until the mid-1970's, the primary concern was how to ensure that there would be enough physicians to meet the demand. In 1964, foreseeing physicians shortages, the first Hall Report (Canada, 1964) recommended increased production of physicians. As a result, four new medical schools were built and enrollment at the older schools was increased. These contributed to a physician boom and physician surplus became a major concern in the mid 1971s. The concern was tied to a hypothesized link between the number of physicians and health-care costs.

This has led to a number of physician manpower studies (e.g., Aziz, 1974; Ontario Council of Health, 1974). Unfortunately, none of the reports however called for an urgent reduction in the supply of physicians. The oversupply of physicians, some believed, will help reduce the poor geographic distribution of physicians (Williams et al. 1983). Therefore, government concern about physician oversupply did not lead to any aggressive measures to cutback supply although some restrictions on immigration were implemented. Another important report was Lalonde's "A New Perspective on the Health of Canadians" (Canada, 1974). In drawing attention to the roles of lifestyle, environment, and health-care organization in determining levels of health, Lalonde questioned the appropriateness of the health care budget allocations - primarily to acute-care hospitals and physicians (see Lomas et al. 1985).

Physician supply continued to increase, albeit at a slower rate than in the early 70s, but outstripping population growth. Between 1975 and 1980, it had grown on an average 2.5 percent per year while population grew only 1.0 percent per year (Health and Welfare Canada, 1981b). This contributed to a 10 percent per annum increase in physician-service expenditures per capita (Lomas et al. 1985).

It was the second Hall Report (Hall, 1980) - Canada's National-Provincial Health Programme for the 1980's - which really emphasized the potential for physician oversupply as an issue of primary concern, and it was this report that addressed the issue of physician manpower in the context of the link between physician numbers and health-care expenditures (Lomas et al. 1985).

At the federal level, a special committee which was appointed to report to the Deputy Ministers of Health suggested a reduction in medical-school enrollment by 10 percent. At the provincial level, the four western provinces began to conduct a large-scale study of health manpower in these provinces. This led to recommendations to cut medical school enrollment by 25-30 percent (Lomas et al. 1985:8). In Quebec, an analysis of physician requirements led to a cutback in residency positions in order to control the supply of specialists. British Columbia's Joint Committee on Medical Manpower also recommended a reduction in medical school enrollment. The Low report (Council of Ontario Faculties of Medicine, 1981), however, recommended an increase of specialists relative to general practitioners. In Ontario, the then Minister of Health Dennis Timbrell, rejecting the Low Report decided to reduce the number of residency positions and also the number of medical undergraduates in the province. Consideration of alternatives to physician-delivered services were also there in the government's policy agenda.

The Minister of Health requested the chairman of the Ontario Council of Health to explore all issues relevant to manpower planning in June 1981. The Council established a special Medical Manpower Task Force under the chairmanship of J. B. Macdonald. The final Macdonald Report (Ontario Council of Health, 1983) which was released in May 1983, recommended an increase in physician supply. As Lomas et al. (1985) noted, following the report, however, there was a growing concensus within other governments and academic circles that controls should be placed on the stock of physicians. During the Commons Committee hearings on the Canada Health Act, one health economist called for the closing down of Queen's Medical School in Ontario (Globe and Mail, 1984; Lomas et al. 1985).

Quebec limited its specialists supply by establishing quotas for each speciality. Provincial legislation (Bill 27) was passed in 1982 to discourage the flow of physicians to major urban areas. There was also a cutback of 10 percent in undergraduate medical school enrollment.

In British Columbia, a bill was passed in 1983 to restrict new physicians' access to the provincial medical insurance programme. Undergraduate enrollment, however, was increased in the province. It also provided greater opportunities to practice medicine for British Columbia residents.

As Aizenman (1982) has noted, physician surplus can have adverse effects. It could plunge the health care system into financial crisis. The issue of costs is compounded because of the peculiar nature of the medical care system in this country. As he stated, "Costs can only escalate, given the present system of unrestricted numbers of physicians and open-ended remuneration and the fact that the demand for medical services seems to depend as much on availability as on need" (Aizenman, 1982:1178). Whereas, the cost to a government of a practicing physician in Canada was estimated at $200,000 in 1978, by 1982 it had grown to $500,000 (see Hatcher, 1978; Penner, 1982; Aizenman, 1982). If the trend continues, there is enough reason to believe that ever-increasing supply of physicians will have negative consequences for our health delivery system by damaging health care budgets. To overcome such threats, government's efforts are needed to address the twin issues of physician (specialists) supply and distribution.

As Lomas et al. (1985: 14-15) wrote,

> "There is little doubt that governments, given a politically neutral implementation environment, would like to achieve at least stabilization, if not outright reduction, in the size of the physician stock... The public debate still continues as to the merits of moderated or reduced physician supply, however, and formally commissioned reports on future physician requirements, such as the Macdonald Report,

> continue to turn up conclusions that are at odds with the desired policy direction."

2.3 Issues and Problems

The introduction of universal hospital insurance and universal medical care insurance has had the effect of increasing the demand for and utilization of health services. The current situation is that these programmes appear to be in danger because of the considerable escalation of costs required to maintain the services; health care expenditures began to consume a growing share of the public sector dollar. Today, "the health care scene appears to be in turmoil; commentators describe health costs as "skyrocketing" and 'out of control' (Bennett and Krasny, 1977:2). Although health-care expenditures as a proportion of GNP remained relatively stable throughout the 1970s, serious concern continued to be addressed. A recent study by Barer and Evans (1986) analyzes health care expenditures in some detail, tracing the patterns of health expediture in Canada and also the behaviour of different components of health expenditures over the post-war period of about thirty-five years. They observed unusually high rates of increase in expenditures for both hospitals and physician's services in the early 1980s; hospital spending (per capita) was up 3.7 percent in real terms (relative to the Consumer Price Index), physicians

5.2 percent, and total health spending 4.2 percent (Barer and Evans, 1986). As they put it, "there appears to have been something of a health spending "breakout" in 1982, even as GNP was falling." (Barer and Evans, 1986:63)

This section focuses on some of the issues and problems facing the Canadian health care system. The following major issues are discussed:

1. financing and costs of health services,
2. manpower and facilities, and
3. planning and organization of health services.

2.3.1 Financing and Costs of Health Services

The federal share of health expenditures is financed by tax revenues. The provincial shares are met in various ways and some provinces have changed their systems of financing over the years, moving especially from premiums to general tax revenue. Newfoundland, Nova Scotia, New Brunswick, and Quebec use general or special tax revenues entirely. Prince Edward Island, Ontario, Manitoba, and Saskatchewan have premium systems, and Alberta, and British Columbia levy co-insurance charges against beneficiaries to meet part of the costs (Statistics Canada, 1985).

The overall cost of health care in Canada, including expenditures by the private sector and by all levels of government, reached about $25.8 billion in 1981 (Table 2.3-1). This figure was up 16.2% from 1978. On a per capita basis, the cost in 1981 represented $1,058; which was up by $332 from 1978 and was almost double the per capita total for 1975 ($545).

As a proportion of the gross national product, the cost of health care services in Canada remained relatively stable during the 1970s; it stayed between 7.2% and 7.5%. The cost, however, jumped from 7.6% in 1981 to 8.4% in 1982.

When health expenditures are classified by type of service being rendered, notable changes over time are observed. The largest component of national health expenditures continues to be institutional care, i.e., hospitals and related institutions (Table 2.3-2). From 1970 on, hospitals have taken three-eighths or more (37.5%) of the health care expenditure. Professional care accounted for the second highest of total health care expenditures (14.5%). Turning more specifically to the provincial situation, in 1981, Quebec spent 3,296 million dollars or roughly 50% of the total expenditure, on institutional care (Table 2.3-3).

As Evans (1984) notes, for physicians' services, the changes are even more dramatic. In the period 1947-1971,

Table 2.3-1

Total Health Expenditures, Public and Private, Selected Years: Canada 1970-1982

Year	Expenditures ($'000,000)	Annual Percentage increase	Percentage of GNP	per capita ($)
1970	6,256	12.9	7.3	293
1975	12,381	14.6	7.5	545
1976	14,159	14.4	7.4	615
1977	15,533	9.7	7.4	667
1978	17,094	10.0	7.4	726
1979	19,067	11.5	7.2	802
1980	22,179	16.3	7.5	921
1981	25,769	16.2	7.6	1,058
1982	30,087	16.8	8.4	1,220

Source: Statistics Canada. 1985. Canada Year Book, 1985. (Ottawa: Statistics Canada)

Table 2.3-2

Percentage Distribution of Health Expenditures, Public and Private, by Category, Selected Years: Canada, 1970-1981

Category	1970	1975	1976	1977	1978	1979	1980	1981
Hospitals	45.0	46.9	46.4	44.6	43.8	43.2	42.8	41.6
Homes for Special Care	7.2	9.2	10.2	11.2	11.7	12.0	12.2	13.7
Physicians	16.6	15.5	14.9	14.9	14.9	14.9	14.8	14.5
Dentists	4.2	4.8	4.9	5.3	5.6	5.8	5.8	5.8
Other Professional Services	1.7	1.4	1.4	1.4	1.4	1.5	1.5	1.5
Drugs and Appliances	12.5	10.5	10.5	10.8	10.8	10.8	10.2	10.4
All Other Health Costs	12.8	11.7	11.7	11.8	11.8	11.8	12.7	12.5
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Source: Statistics Canada. 1985. Canada Year Book, 1985 (Ottawa: Statistics Canada).

Table 2.3-3

Total National Health Expenditures, Public and Private, by Province: Canada, 1981

Category	Nfld.	PEI	NS	NB	Que.	Ont.	Man.	Sask.	Alta.	BC	Yukon and NWT	Total
	(Million Dollars (percentages in parantheses))											
Hospitals	228 (44.2)	36 (30.5)	398 (45.5)	263 (39.8)	3,296 (49.6)	3,479 (38.7)	454 (40.3)	385 (39.1)	960 (36.9)	1,187 (37.3)	40 (52.6)	10,724 (41.6)
Homes for Special Care	67 (13.0)	21 (17.8)	114 (13.0)	120 (18.2)	904 (13.6)	1,356 (15.1)	200 (17.8)	148 (15.0)	296 (11.4)	301 (9.5)	3 (3.9)	3,531 (13.7)
Physicians	53 (10.3)	14 (11.9)	112 (12.8)	68 (10.3)	838 (12.6)	1,490 (16.6)	141 (12.5)	124 (12.6)	353 (13.6)	542 (17.0)	8 (14.5)	3,741 (14.5)
Dentists	12 (2.3)	5 (4.2)	36 (4.1)	23 (3.5)	284 (4.3)	603 (6.7)	61 (5.4)	55 (5.6)	140 (5.4)	262 (8.2)	2 (2.6)	1,483 (5.8)
Other Professional Services	2 (0.4)	1 (0.8)	6 (0.7)	7 (1.1)	94 (1.4)	148 (1.6)	15 (1.3)	14 (1.4)	51 (2.0)	50 (1.6)	- -	389 (1.5)
Drugs and Appliances	93 (18.0)	15 (12.7)	133 (15.2)	91 (13.8)	554 (8.3)	956 (10.6)	110 (9.8)	144 (14.6)	226 (8.7)	358 (11.2)	4 (5.3)	2,684 (10.4)
All Other Health Costs	61 (11.8)	27 (22.9)	76 (8.7)	89 (13.5)	679 (10.2)	951 (10.6)	144 (12.8)	113 (11.5)	574 (22.1)	486 (15.3)	19 (25.0)	3,217 (12.5)
Total Expenditures	516 (100.0)	118 (100.0)	875 (100.0)	660 (100.0)	6,648 (100.0)	8,983 (100.0)	1,126 (100.0)	984 (100.0)	2,600 (100.0)	3,185 (100.0)	76 (100.0)	25,769 (100.0)
Per Capita ($)	909	959	1,032	948	1,032	1,041	1,096	1,015	1,157	1,158	1,091	1,058

Source: Statistics Canada, 1985. Canada Year Book, 1985. (Ottawa: Statistics Canada).

the income of average physician in Canada rose from 3.26 times that of the general taxpayer to 5.57 times. A large part of the increase in expenditure on physicians services from 1946 to 1971 was, "in fact, a price/income phenomenon, which did not increase the "opportunity cost" of medical care or have any effect on anyone's health status, but merely transferred wealth from Canadians generally to physicians"(Evans, 1984:15).

Health care costs in Canada have risen slightly over the past two decades (from 5.6% in 1960 to 8.4% in 1982) as a percentage of gross national product, but compared to many other industrialized countries, Canada's rate of increase has been low. The major concern, however, is the rising cost relative to gross national product. The Task Forces on the cost of health services were set up essentially to make recommendations which can be used in reducing the rate of increase in costs. Also, the Economic Council of Canada's report, Patterns of Growth (Economic Council of Canada, 1970) reported that the cost of health care required "urgent attention". These reports were followed by a succession of reports and studies echoing essentially the same theme: the cost of health care is 'out of hand'. The seriousness of the problem was earlier stated in Manitoba's White Paper on Health Policy (Manitoba, 1972), which reports:

> "The quality and quantity of health care have been endangered by the alarming increase in total health costs of the past several years, and the still more alarming projections for the years ahead, which show at the moment only an unhappy choice between the continuation of the trends from the recent past - virtually intolerable - or short-run measures that freeze particular costs while workable policy for the long-run is devised ... Standards of health care are threatened, and for all income groups" (Black et al. 1978:1).

Several recent studies have voiced serious concern about the continuous growth of health care expenditures (Barer and Evans, 1986; Evans, 1987; Maxwell, 1987). All agreed that health care does not come cheaply but cost-effectiveness of health care should be of utmost concern especially when the annual federal deficit runs at $30 billion and the public health expenditures exceed $25 billion (see Maxwell, 1987:1). As earlier noted, Barer and Evans (1986) undertook an exhaustive analysis of the issue of health care costs. They noted that while all components of the health care budget have increased over the past decade, recent trends demonstrate a tendency for costs for physicians' services to escalate faster than those of the institutional sector (see also Loon, 1986). In other words, the primary driving force has been the rapid increase in the supply of physicians. Barer and Evans (1986) have noted that, having little control over physician supply and physician income, governments have turned to squeezing the overall budgets and acute-care bed supply in the hospital sector.

The government's targets for cost-containment are in the hospital sector, the health professional sector, and the educational programme sector. A major approach involves limiting the supply of health manpower, hospital beds and equipment such as Computed Tomography (CT) scanners. Another proposal to curtail health care costs involved promoting community health centre facilities. The Hastings Report (Report of the Community Health Centre Project, 1972) advocated community health centres as an integrated team approach to the provision of primary care. But since the publication of the report, there have been few such centres established. As Coburn et al. (1987:659) have noted, "the community-health centre concept is too strongly opposed by medical and hospital associations and some civil servants and politicians, to make any headway unless some crisis develops." Other efforts include providing preferential funding to ambulatory and day care facilities and decreasing the ratio of specialists to general practitioners.

The increases in health expenditures stem from a variety of sources such as changes in the size and composition of the population, changes in the quality of services, changes in the quantity of services per capita, and changes in the price of each service (Soderstrom; 1978:239). More importantly, it has been argued that the proportion of people aged 65 and older is increasing, and since the elderly need more care than any other segment of the population, the burden on the system will steadily increase. For example, there is evidence that persons aged 65 and older need nearly eight times as many hospital beds as those under 45 (Bennett and Krasny, 1981:46). Today, with ten percent of the population aged 65 and over, Canada is one of the oldest countries. By 2031, it is estimated that the proportion of elderly will rise to 20% of the population and will consequently need 60% of hospital patient days (Ableson et al. 1983:11). In addition, it appears that the cost of medical care required to treat chronic and degenerative diseases such as arteriosclerosis and tumors more commonly diagnosed in older patients will continue to drive up the overall cost for care.

2.3.2 Manpower and Facilities

The expansion of health manpower and facilities has taken place during the post-war period but has been especially marked since the Report of the Royal Commission on Health Services in 1964 which recommended an increase in physician supply, aiming to have 175 doctors per 100,000 population by 1990 (Canada, 1964). Consequently, medical schools in the country nearly doubled their output of graduates by creating four new medical schools and expanding some of the existing programmes. In addition, the 1970s witnessed an increase in immigration of foreign medical graduates. The result was 175 physicians per 100,000 population fourteen years ahead of schedule. Prior to 1975, almost as many immigrant medical graduates as Canadian medical graduates were added to the stock of physicians each year; but, the number of immigrant physicians has been decreasing since 1975 (Statistics Canada, 1985). The stock of physicians as it relates to the population reached 1:538 in 1981, surpassing a ratio set by a national physician requirements committee established by National Health and Welfare Canada (Statistics Canada, 1985). The total number of physicians (including interns and residents) has increased about 38% from 1971 to 1981; an alarming increase from the point of view of cost.

In the early 1980s (1981/82), health manpower includes more than 45,000 physicians, 230,000 registered nurses, 11,000 licensed dentists and a large number of other health professionals in such activities as diagnostic treatment, rehabilitation, public health and health promotion (Statistics Canada, 1985:94). Services are provided in nearly 1,300 hospitals and more than 5,000 extended care facilities. The hospitals account for more than 50 million patient days in a year and a substantial amount of outpatient care. In other words, patients spent nearly 50 million days in public hospitals. One out of every six persons in Canada is admitted to hospitals each year, the largest rate in the Western world (Bennett and Krasny, 1977:11). Admission rates vary by 67% between Quebec, which uses hospitals least, and Saskachewan, which uses them most. Costs related to supplies and employee benefits are the main component (32.2%) of hospital expenditures in Quebec (Statistics Canada, 1985).

National funding supported the growth of the health care industry. The National Health Grant of 1948 through its Professional Training Grant had encouraged several provinces to provide training grants to medical, dental, and nursing students in return for a period of service after graduation (Hastings, 1971). Also, the Hospital Construction Grant assisted provinces in constructing hospitals, thus, emphasizing hospital care and diagnostic services. Similarly, the Health Resources Fund (1965) provided for assistance in building, expansion, and renovation of educational training and research facilities (Hastings, 1971).

The Saskatchewan's Medical Care Plan (1962) led to the establishment of citizen-sponsored community clinics

(Hastings, 1971). Its purpose was to make use of all available skills in a cooperative work setting and remove a significant portion of care from general hospitals in which care is expensive. Quebec, and Manitoba followed Saskatchewan in implementing the recommendations made by the 1972 Report of the Community Health Project (Canada, 1972).

During the 1950s and 1960s there was a considerable emphasis on specialization in medical profession (LeClair, 1975). When the Hospital Insurance Programme made its appearance in 1958, the salaries of interns and residents were covered under the programme, thus increasing residency and internship positions in hospitals. As a result, between 1958 (when hospital insurance started) and 1968 (when Medicare was established), general practitioners, as a percentage of active civilian physicians, declined from 60% to 50% while specialists increased from 40% to 50% of the total physician supply (LeClair, 1975:56).

The increased number of specialists resulted in an increased concentration of physicians in large urban centres because specialists are mostly attracted to hospitals where special facilities and equipment are available (LeClair, 1975). At the same time, physicians practicing in rural areas declined and were not replaced proportionally (LeClair, 1975).

The introduction of medicare clearly enabled expansion of physician/population ratios through immigration and heightened output of medical schools. First-year enrollment in medical schools almost doubled from 970 a year in 1960-61 to 1887 in 1980-81 (Ryten, 1985; Coburn et al. 1987). As Coburn et al. (1987:656) have noted, "the guaranteed incomes generated by medicare freed medicine from the imperative of controlling the supply of practitioners." Medicare also provided a means for provinces to subsidize or otherwise encourage physicians to locate in "under-doctored" areas (Leclair, 1975:56). A major concern confronting planners and policy makers, however, is the maldistribution of physician services. Medicare and hospitalization schemes have improved access to health services, but disparities remain among regions and among socio-economic groups.

2.3.3 Planning and Organization of Health Services

Effective planning of health services has long been the concern of both the federal and provincial governments. Special commissions, committees, task forces, consultant studies and projects have been used for the purpose.

In recent years, health planners have advocated that Canada should adopt the decentralized and geographically-oriented approach to health care delivery. More specifically, the approach involves "the decentralization of the delivery system for health and related social services to the local or community level and integration of these services under the aegis of a single authority" (Black et al. 1978:94).

The Task Force Reports on the Cost of Health Services (Canada, 1970) recommended a restructuring of the health system by the establishment of regional planning boards and regional hospital boards. In the same year three provinces - Ontario, Quebec and New Brunswick - recommended the regionalization of health services. Thus, The Report of the Ontario Council of Health (Ontario Council of Health, 1970) proposed the adoption of a two-tiered regional organization and Quebec's Nepveu -Castonguay Report (Quebec, 1970) recommended sweeping changes in the system through regionalization of services. Also, in 1970, through a report on hospital facilities to the government, New Brunswick recommended regionalization of services on both cost and quality grounds (New Brunswick, 1970).

Following the lead of Ontario, Quebec, and New Brunswick, Nova Scotia recommended regionalization of health services. The 'Report on an Integrated System of Hospital Facilities and Related Studies' (Nova Scotia, 1971) argued that "regionalization would facilitate coordination between all levels of care; would prevent unnecessary duplication of services, manpower and equipment; would improve consumer participation; and improve quality of care" (Black, et al. 1978:95).

A major issue proposed in Manitoba's White Paper on Health Policy (Manitoba, 1972) was regionalization. The White Paper advocated the integration of all health and related social services at the local level under the authority of district health boards. The district health authority should have responsibility for planning, management, and budget and allocation of funds to programmes and health facilities in the community.

The Hasting's Report on The Community Health Centre in Canada (Canada, 1972), and the Foulkes Report in British Columbia (British Columbia, 1973) also recommended regionalization. Further, Ontario's Report of the Health Planning Task Force (Ontario, 1974) advocated the establishment of 'district health councils' for planning purposes and 'area health service management boards' in order to operate health facilities.

Despite widespread consensus in support of regionalization, it is surprising to notice that the provinces have accomplished very little in this direction. Bennett and Krasny (1977:15-16), have identified four major barriers that have prevented regionalization from fullfilling its promise:

> 1. "No organizational structure has been found that can effectively do the job;
>
> 2. The momentum of the current system, particularly its insatiable appetite for money, is too great for any group to have a significant impact in the short term;
>
> 3. Entrenched and parochial interests oppose every rationalization or even add-on decision; and
>
> 4. Regional bodies do not have the skills to cope with the general management job of planning care delivery for an entire area."

The development of community health centres has been supported by many as a more economic, accessible, and effective method of delivery of health care. As was discussed previously in this chapter, the Task Force Reports on The Cost of Health Services (Canada, 1970) recommended the construction of community health facilities as a cost-containment effort. The development of community health centres has been supported by Quebec's Castonguay Report (Quebec, 1970), Manitoba's White Paper Report (Manitoba, 1972), and British Columbia's Foulkes Report (British Columbia, 1973). The 'Hastings Report' (The Community Health Centre in Canada) published in 1972 presented the findings of an exhaustive study of health centres set up by the federal government on behalf of the federal-provincial ministers of health (Canada, 1972). The study stressed the importance of health centres in achieving cost-reduction in the delivery of health care.

Again, as with regionalization, given the greater support for health centres, little has been done to develop community health centres. According to some analysts, "the investment to date in the existing health centres has not been sufficient to bring them over the resource threshold that is essential before they can even begin to demonstrate economies" (Black et al. 1978:104). Also, as Hastings (1972) pointed out, insufficient number of health centres in the system makes it difficult to make an effective evaluation.

Another recommendation is directed toward the remuneration for physicians. There are recommendations for abandoning the existing fee-for-service payment system for physicians and introducing a salary payment system. It has been argued that the fee-for-service system is inappropriate in group practice and community health centre settings (Black et al. 1978:107). "Under fee-for-service, the doctor who delegates tasks to others loses income. The system encourages him to provide many services which could be provided by other skilled health workers" (Manitoba, 1972:21). A salary system, on the other hand, is believed by some to have the advantage of improving the distribution of physicians and hence providing equality in access to medical services. Geographical differentials in salary could help to compensate for some of the advantages that may be obtained by practicing in urban centres. It is believed that a salary system has also the advantage over the fee-for-service system in providing public control over the allocation of resources that are being financed.

While the average person in Canada appears to be satisfied with the present health system, there is a growing concern that further changes are needed to ensure "the right care to the right person at the right time in the right place and to the right price".[3] In essence, as Professor Courchene remarked, in the health care sector "we face the same three conflicts we face in every other area of the federal system: centralization vs decentralization, public vs private, and efficiency vs equity" (see Watson, 1984:50).

CHAPTER 3

Health Manpower: A Review of Models and Empirical Analyses

For planning purposes, a great deal of basic information and theory is needed on the variables which influence locational dynamics of physicians and the linkages. This is the emphasis of this chapter. We begin by looking at models used to forecast physician requirements, demand for physicians, and the distribution of physicians. Much of this review stems from an article by Lave and his associates (1982). After a review of the available models, we consider evidence on the factors that influence physician location, both at the level of the individual and in the aggregate.

3.1 Manpower Models: Supply and Demand

A number of approaches have been used by health manpower planners to forecast the need for, demand for and supply of health manpower at a specific time and place. The basic models for estimating these requirements include those based on:

(i) professionally defined criteria;

(ii) current utilization rate of comprehensive pre-paid group practice;

(iii) physician/population ratios;

(iv) economic models; and

(v) models of physician supply.

The classic approach to developing manpower requirements based on professional consensus of standards and needs was developed by Lee and Jones in 1933. The approach consists of four steps as noted by Lave et al. (1982:307): determining the incidence of illness by type in a population; polling experts to determine the amount of services required to diagnose and treat the illness; estimating the average number of services provided per hour by a health provider; and securing professional opinion on the average number of hours per year a provider spends in caring for patients. Lee and Jones (1933) estimated a need for 135 physicians per 100,000 population (instead of the 126 per 100,000 existing when the study was conducted) for all medical services in the United States (see also DiLisio, 1981).

The Lee and Jones' study was replicated by Schonfeld et al. (1972) almost 40 years later. Based on interviews of internists and pediatricians, and morbidity data from the United States National Health Survey, they estimated a need for 133 physicians per 100,000 population for primary care alone. These estimates are clear indications of a wide gap between need and supply since Schonfeld's estimates reflected only a portion of care, whereas the Lee and Jones estimates were for total medical care.

The professional consensus approach has several deficiencies. Its principal problem, as Lave et al. (1982) note, is that the actual demand for care is far less than that predicted by the model, since not everyone who needs care seeks it. Thus, policies based on the Lee and Jones' approach would lead to an oversupply of physicians. Further, the standards established are only average estimates; there can be great variations among regions and subgroups of population. In general, the approach is too narrow because it looks at "need" strictly from a professional view point.

The second normative approach is based on evidence from prepaid group plans. It has been argued that the observed demand for manpower in specific prepaid group practice such as the Kaiser System plans in the United States is the best guide for manpower planning.

The Kaiser system is composed of numerous different local plans. The number of physicians per 100,000 population as well as the population served vary across plans. As Lave et al. (1982) note, the variability across plans is so strong that fixed ratios make little sense.

What factors contribute to the variability in ratios across plans? Are the populations served different? These questions have not been answered when using estimates derived from such prepaid group practice programmes.

The physician to population ratio is an empirical approach that has long been used to assess the adequacy of physician supply. In this approach, some current physician/population ratio is considered for the future. There are variations in selecting the ratios: (1) the current average ratio in the United States is taken as the minimum required ratio at some future time; (2) the ratio from states with the highest physician/population ratio (the criterion ratio) is taken as the minimum required ratio at some future time; and (3) the ratio is calculated for each demographic group in a place where the population is deemed to be adequately served.

The main advantage of the ratio approach is the simplicity with which it can be applied and the limited data requirements. Several problems with the approach have been discussed elsewhere (Lave et al. 1982). The underlying assumption is that more physicians indicate better health. Therefore future requirements are set too high. National ratios mask the great variability in physician distribution by state, county, and type of practice.

Suppose, for example, that enough physicians are trained to raise Canada's physician/population ratio to the level of Ontario (as of 1981). There is little reason to believe that these newly produced physicians will choose to practice in provinces with relatively fewer physicians, or in areas within provinces that have the lowest ratios. Lave et al. (1982:312) suggest that the health care "system is more fluid than the ratio approach implies and that policies should encourage flexibility, not fixed ratios." The approach suffers from an absence of control for factors known to be important determinants of physician location. For example, what aspects of urban environments attract physicians and what in rural communities repel them?

Economic models address the question of demand for services at a specific time and place. While the ratio approach does not take account of factors that affect physician services, the economic models go far in allowing one to gain insight into the factors that influence physician location. The models allow one to predict what effect changing socio-economic or demographic characteristics of the population will have on the demand for medical care. The economic models are unsatisfactory in two important ways. First, as explained by Lave et al. (1982), they do not take account of crucial variables, travel time and cost. Sophisticated economic models at the micro level have been developed to forecast demand at a given time and space (Yett et al. 1972). However, lack of data for use with such models involving a series of equations and variables has inhibited the use of these models for planning purposes.

Physician services might be measured by the number of physicians (hours of service) by speciality and location. Thus, one must know the current stock of physicians, changes in the stock; factors affecting type of practice; and factors affecting geographical location. While there have been studies addressing these issues, there has been little formal modelling and empirical investigation. Determining (mal)distributions of physicians and studying the factors associated with them are central policy issues since many governments have responded to spatial inequalities by elaborate, and often expensive, intervention into the local health delivery system (Lave et al. 1982).

Three techniques have been used to study distribution of physicians and the factors causing it. By far the most common involves a simple tabular comparison of physician/population ratios across regions/states/counties and the extent of maldistribution is identified with the range of the ratios (Fahs et al. 1968; DeVise, 1973). For purposes of policy formulation, such simple comparisons of ratios represents only first steps because as noted earlier they do not take account of factors affecting physician/population ratios.

The second most common approach employs multivariate statistical analysis (such as regression) and represents an advance over simple tabular comparison of physician/population ratios. Studies using these methods attempt to relate physicians of a given locality (at levels of aggregation such as region, state, county, or census tract) to characteristics or attributes of the locality that are presumed to act as positive or negative inducements to physicians. These are often considered as well formulated models of physician spatial behaviour (Lave et al. 1982). Some of the variables, as the authors noted, can be modified by a deliberate policy formulation and hence can provide a basis for choosing among alternative policies.

Although this approach is superior to crosstabulation of ratios, it is not without problems. Ordinary Least Squares (OLS) has often been used in these analyses, but it sometimes fails to give accurate estimates of relationships because of multicollinearity or simultaneous influences among the variables (see Lankford, 1974). Other problems include the assumptions that must be made concerning independence and normality in the distribution of errors and linearity of the equation (Lave et al. 1982). Also cause and effect relationships cannot be inferred, and all one can justifiably do in such analyses is to indicate the apparent strength of (non)existence of spatial association (Stimson, 1983). The fact that a researcher cannot test the theories with the regression approach in a routine way, is a major disadvantage. If the analysis demonstrates a strong degree of spatial association, then it is necessary to design a research strategy and test statistically for causality, if any, at that scale. The problem then is to use different estimation procedures for recursive and nonrecursive models to test causal order of the variables.

The third approach involves surveying physicians to ascertain from physicians themselves the factors regarded as most important in their choice of a practice location. Clearly, this approach has the potential of uncovering background characteristics of physicians that influence them in long-term choices for particular location. However, construction of models to reflect individual behaviour often cannot be realized in the absence of attitudinal surveys. As Lave et al. (1982) have noted, both attitudinal surveys and spatial models are useful for policy formulation. While "surveys help determine which background qualities of physicians make them better long-term choices for rural locations" (Lave et al. 1982:318), spatial models could reveal whether certain amenities available in an area lead more physicians on average to choose a particular type of locale.

A supply model of physicians is used in this study focussing on the spatial distribution of physicians and the factors causing it. In general, the question that has been phrased is this: what are the characteristics of the areas the physicians favour and of those they avoid? The underlying assumption is that by understanding the attractive factors policies can be instituted to modify the availability of physicians in underserviced areas and thus improve the distribution.

3.2. Physician Distribution: A Review of Literature

The desire to ensure a more equitable distribution of health services has prompted a vigorous interest in the distribution pattern of physicians around the world. This interest has stimulated a vast body of research on physician distribution, particularly in the United States. The focus of this research has been the examination of the factors that influence and motivate individual physicians to set up practice in specific locations.

If the findings of these studies are to serve as a foundation for national policy and as a meaningful guide for future research on physician distribution, then a review of some of these studies is essential. The purpose of this chapter is to provide a brief review of selected literature which has proliferated on the subject of physician distribution.

As earlier noted, investigation of physician distribution has focussed on two major areas. One approach views the distribution in individualistic terms, i.e., in terms of the characteristics and preferences of physicians (e.g., Weiskotten et al. 1960; Rimlinger and Steele, 1963). A second and perhaps more promising approach involves the structural or aggregate approach, which focuses on the attributes of communities which are being selected as practice sites (e.g., Marden, 1966; Joroff and Navarro, 1971; Reskin and Campbell, 1974). The two approaches are treated separately whenever possible in the following discussion. Following a brief review of the literature and a brief discussion of some criticisms of the existing research, theoretical orientations and research findings will be brought directly to bear on the problem of the present study in the final section of this chapter.

At this point, a few cautionary comments should be made. First, the studies to be reviewed are sometimes rather arbitrarily assigned to the sections in which they appear. The reason for such categorization is that, in the author's view, they more or less illustrate that category of research. Secondly, most of the material discussed in this chapter concerns physician distribution in terms of factors affecting it. However, in a few instances, the discussion is broadened to include other studies, particularly in the case of Canadian literature. Thirdly, it is important to mention that all those reviewed do not fully explain the perspective used in the present study. Neverthless, their inclusion is justified in terms of the contribution they make to the understanding of the phenomenon of physician distribution.

3.2.1 American Literature

Physician distribution in America has been quite thoroughly documented, in contrast with the situation in other countries. A substantial part of our knowledge of factors affecting physician distribution is based on the results of studies conducted in the United States. This section is intended to select systematically from the vast American literature on physician distribution, articles which have direct relevance to the problem at hand. Following a discussion of the American literature, attention will be given to the sparser Canadian literature. In order to discover the developments in approaches, both theoretical as well as methodological, we will look at the evidence chronologically.

Individualistic Approach to Physician Distribution

Literature on physician distribution focussed on values and attitudes of physicians can be addressed in three broad contexts. The first includes a set of personal characteristics of physicians: their family and geographic origins, their educational experiences before medical school, their personal tastes and preferences. The second includes physicians' educational experience in medical school and residency training. The third involves physicians' economic motivation and business orientation.

Personal factors

The effect of prior attachment to a specific type of community or to a particular geographic location upon the ultimate practice location of physicians has been studied by some investigators. Weiskotten and his associates (1960) and Bible (1970), for example, looked at the tendency of physicians to practice in communities of approximately the same size as those in which they were reared.

Place of prior residence and training is the focus of an extensive follow-up survey of American medical school graduates conducted for the American Medical Association (AMA) by Weiskotten and his associates (1960). The authors found that one-third of the 1950 medical school graduates practiced in the city of their residency training, one in four practiced where they graduated from high school, and even fewer practiced where they interned or attended medical school. These authors concluded that the place of residency was more influential in physicians' located choice than place of medical school. A close association was also found between size of city of practice and size of prior residence of physicians.

Bible (1970), in his survey of 1853 physicians practicing in non-metropolitan areas in the United States in 1967 found a significant relationship between size of place where the physician practiced and size of place where he was reared. The author noted that small-town physicians and their wives had predominantly small-town backgrounds, and physicians in non-metropolitan cities of 25,000 or more population were generally from cities of that size.

In finding a place to practice medicine, either home-town preference or suggestion of friends was most often reported, followed by place of internship as well as assistance of State and AMA physicians' placement services.

Professional stimulation in their work environment is a major determinant of physicians' career choices. The study by Cooper and his associates (1975), supports this argument. In a survey of primary care physicians who graduated from medical school in 1965, the largest number reported that their location decision was influenced by the opportunity to join a desirable partnership or group practice.

A behavioural approach to analysing physician distribution was conducted by Knox and Pacione (1980) in the United Kingdom. These authors surveyed students in their final two years of medical school in Dundee and Glasgow, Scotland. The students were asked to assess the potential importance of a predetermined set of factors in their choice of practice location, and to indicate preferred place of location, by region within Scotland and by neighbourhood within the city in which medical schools were locatecd.

Knox and Pacione (1980) noted the importance of professional and lifestyle-related considerations in the locational decision-making. Interestingly, financial incentives appeared to play only a minor role in the decision-making of these medical students.

Education factors

A number of studies have focused on the relation between the location of residency training and physicians' choice of practice location. Fein and Weber (1971), for example, suggested that physicians probably select a residency training programme in an area where they intend to practice, thus, refuting the findings of Weiskotten and his associates. Yett and Sloan (1971) defended the Weiskotten position through their study of location decisions of newly trained physicians. Findings of their work indicated that residency is a strong determinant of practice selection. These authors found that the greater the number of attachment "events" in the life of respondents (e.g., birth, medical school training, internship and residency) occuring in a single location, the higher the probability that the physician would choose to practice in that location. Also, the most recent attachments were found to have the most significant influence on practice location. Knox (1982) has suggested 'professionalization' of physicians to be a key element in the movement toward specialization and, therefore, in the historical evolution of health care delivery system. In Great Britain, for instance, professionalization of physicians can be traced back to the second half of the nineteenth century and occured in response to concern over the threat of unorthodox therapeutics, the 'overcrowding' of the orthodox profession, and a desire for the upward social mobility that would result from the enhanced professional status (see also Joseph and Phillips, 1984). Knox and Bohland (1983) and Knox et al. (1983) have reported similar considerations in the emergence of professionalization in the United States.

Economic factors

One group of researchers has placed special emphasis on the possible link between economic factors including differences in incomes, fees and training costs and physician distribution. For example, studies by Rimlinger and Steele (1963; 1965) describe a specific relationship between income, population, and physician supply. The authors concluded that prevailing pricing practices, which are major determinants of physician incomes, contribute to the differences in physician-population ratios between areas with varying levels of income and also between urban and rural areas.

On examining the changes in physician location between 1950 and 1960 in response to population and income changes in counties, the authors arrived at these conclusions: (1) The two most important factors affecting the change in location of physicians are the regional degree of urbanization and the increase in population; and (2) Increase in per capita income is a factor attracting physicians, but only in lesser and greater metropolitan areas.

Benham and his colleagues (1968) attempted to construct supply and demand equations describing physician distribution. Their study investigated the distribution of the national stocks of medics (physicians and dentists) in terms of the distribution of population, effective demand for medical service, barriers to migration, and the locational preferences of medics. The authors obtained a negative coefficient for medics' income in their demand equation and a positive coefficient for their supply equation. According to the authors, higher income causes medics to migrate with the effective demand for their services. Effective demand for medics' services, on the other hand, was found depending primarily upon its population and secondarily upon its per capita income.

Other more general studies, such as those by Hambleton (1971), also point to the apparent influence of economic factors on physician distribution. The findings indicated that physician location is dependent not only on wages but also on the costs of medical practice and the returns from recreational facilities (measured by availability of beach areas and camp sites and per capita public recreation expenditures). The author also found that specialists are more concerned about their productivity and leisure activities whereas general practitioners are more concerned about the demand for their services.

Disekar and Chappell's (1976) analysis of practitioners in the United States suggested a partial indifference to economic motives. A similar finding was observed among the Scotish medical students surveyed by Knox and Pacione (1980). Also, Bernstein and his colleagues (1979) in the United States indicated failure of attracting physicians to small towns despite offers of a guaranteed minimum income and adequate office space.

The picture emerging from the foregoing discussion is that the direction of causality between location of medical training and location of practice has yet to be established clearly (see Scheffler et al. 1979). Also what has been presented indicates that the income of an area is not the primary criterion by which physician location is determined. Although recreational facilities were shown as important factors affecting distribution of physicians, and in particular, the distribution of specialists, the effect of these factors has not been adequately evaluated, perhaps due to the difficulty of measurement and availability of necessary information.

Structural Approach to Physician Distribution

A large segment of the physician distribution literature involves the structural or aggregate approach. The distinguishing characteristic of such an approach is that variables used are characteristics of groups, either characteristics of individuals or of the group's organization. This section provides a brief review of studies employing the structural approach to physician distribution. However, before turning to a discussion of these studies, it is important to review the classic study in human ecology which stimulated this work.

The classical human ecologists and economists theorized that relationship exists between size of population in a given area and the number of institutions serving that population (e.g., McKenzie, 1933; Hawley, 1941). Hawley (1941), for example, examined the relationship between urban service institutions and certain demographic variables such as population size. He found that the size of population affects in some more or less direct manner the number and variety of institutions associated with it.

At the conclusion of his study, Hawley invited other investigators to explore the problem by extending the analysis to include other types of institutions and different demographic variables. While many contemporary researchers expressed concern for the relationship between service institutions and population variables, little evidence of any attempt to extend Hawley's research is apparent. This prompted Hawley to point out almost two decades after the publication of his original work that his work was preliminary and cannot be considered as authoritative and definitive (Hawley, 1959). This, however, stimulated further research and institutionalized services, namely, the medical services were found as an appropriate area where Hawley's approach can be usefully applied.

Marden (1966) responded to Hawley's request through his investigation of the distribution of physicians in 204 Standard Metropolitan Statistical Areas and 165 cities in the United States. With the use of multiple regression analysis, he tested Hawley's basic argument that urban service institutions reflect the demographic and environmental structure of their locale.

The findings suggested that the most important variables affecting distribution of general practitioners are age and race of population. As a determinant of specialist distribution, the author found level of education of the population to be the most significant variable. The findings indicated that number of hospital beds is not significantly related to distribution of general practitioners. A quite different pattern was found for specialists. Marden suggested that education of the population could be coupled with medical environment (number of non-federal acute hospital beds) to serve as a major factor explaining the distribution of specialists.

A similar study was carried out by Joroff and Navarro (1971) for the metropolitan areas of the United States. While Marden made a distinction between general practitioners and specialists, Joroff and Navarro went still further and divided physicians into 27 groups. The authors found that the effect of race on distribution of general practitioners is negligible, whereas the percentage of population 65 or older is the single most important variable positively influencing the distribution of this group of physicians. Consistent with the findings of Marden, these authors found the education level of the population to be the most significant variable positvely affecting certain specialty groups.

Elesh and Schollaert (1972) set forth a demand supply model for the distribution of physicians in the city of Chicago, comprised of eight factors: four affecting demand and four affecting supply. The model consisted of population, four population composition factors, and three ecological factors. Physicians were divided into primary care physicians and physicians in private practice. The former included, in addition to general practitioners, internists, obstetrician-gynecologists, and pediatricians, and the latter included all other physicians in private practice.

The findings suggested that population size and composition (i.e., size of tract population, proportion young and old, and education) are the most important variables having positive effects on physician distribution. The authors argued that physicians, and, in particular, general practitioners do avoid practice in areas where a large proportion of the population is black. However, the desire to avoid such areas can be overcome if aggregate areal income is raised to an extremely high level suggesting a threshhold value in physicians' locational response to income.

Rushing and Wade (1973) examined changes in physician ratios between 1950 and 1962 for 21 Tennessee counties and between 1950 and 1966 for 74 other counties in the United States. The distribution of physicians was compared with that of other professional and technical personnel in terms of certain community characteristics. The average per year change in county physician ratios were regressed on county median family income for 1960 (roughly the midpoint for the 1950-1962/1966 period).

The findings of their work can be summarized as follows:

(1) physicians are unequally distributed depending on the socio-economic characteristics of the communities;

(2) the distribution of physicians as patterned on these characteristics resembles the distribution of other technically trained personnel, both within and outside the medical field; and

(3) increase in the physician ratios are directly related to county wealth; county wealth, on the other hand, is not related to the change in distribution of hospital facilities.

A study by Reskin and Campbell (1974), examined the effects of demographic and ecological variables on the distribution of physicians in 22 greater American metropolises with populations greater than one million. They divided the total number of physicians in full-time nonfederal private practice into general practitioners and six medical specialty groups.

The findings indicated that general practitioners are in greater abundance in areas where morbidity and disability levels are high, specialists were also found responsive to such demands, but general practitioners were more responsive. The authors found that specialists were distributed primarily with reference to characteristics of the medical environment, although socio-economic and demographic factors were also important. Consistent with the findings of Marden (1966) and Elesh and Schollaert (1972), they found that general practitioners are also more abundant in areas where income levels are higher and where a large proportion of the potential clients are white.

These authors also suggested that osteopaths as well as interns and residents may well provide functional alternatives to private physicians suggesting that certain specialties are highly dependent on one another.

Dunn and Doeksen (1977) studied 77 counties of Oklahama to examine the relationship between per capita numbers of health care personnel (physicians, dentists, nurses, pharmacists, radiologists, dieticians, and physical therapists) and selected demographic and socio-economic variables such as population size, population composition, income, and education.

The authors concluded:

(1) to support a high level of health care personnel and services in general, "a prosperous area", i.e., an

area with a relatively large well educated high income population and with a relatively small proportion of poor and minority population, is a primary criterion; and

(2) the communities that are able to support relatively high physician rates, relative to other personnel rates, are characterized by large populations. Conversely, those with few physicians relative to other health personnel are characterized by small populations.

It appears that most research has followed Marden's lead and has viewed physician distribution as a direct consequence of demographic, socio-cultural, and economic factors. More recent studies (e.g., Anderson, 1977; Foley, 1977) have begun to broaden the area of enquiry and analyze physician distribution in a causal framework.

Anderson (1977) tested a causal model of the health services system serving the state of New Mexico. He examined the causal relationships among a set of social, demographic, and economic variables that are related to the supply and use of health manpower and facilities, and to the health status of a population.

The author's basic findings of direct relevance here are:

(1) as a county urbanizes, the general practitioners -population ratio declines;

(2) a change in the non-white population in a county results in a change in the supply of general practitioners. The general practitioners-population ratio declines as the non-white population of a county increases;

(3) the supply of medical specialists is more sensitive to changes in the medical environment of a county than is the supply of general practitioners; the supply of hospital beds increases as the supply of specialists increases; and

(4) the supply of specialists increases with the educational level of the population.

Foley (1977) analyzed the relationship between community social structure and local health care system for 274 counties in the United States using a causal model. Local health practice differentiation was measured through a hierarchical Guttman Scale instead of the usual ratio measures of medical practitioners to the population.

The findings indicated that population size and the degree to which a community is an educational and cultural centre (measured by the number of colleges and universities) are causally related to local health care differentiation through the extent of health support facilities (measured by the number of hospital beds in a community). Population size had a larger impact on the index of health care differentiation through the intervening variable, number of hospital beds, than it had directly. The number of colleges and universities, on the other hand, had a strong direct effect on the health care index. Finally, median family income was the single most important variable with a direct effect on health care differentiation.

In the United States and Australia, the distribution of suburban commercial nodes has been noted to be an important influence on physician location (Miller, 1977; Stimson, 1980), while in Britain, Knox (1978) observed fewer surgery locations in suburban housing estates and heavy concentrations in deprived inner-city areas.

The foregoing discussion considered two lines of development in the empirical works on distribution of medical practitioners. The first of these focussed on factors that motivate the individual physician in making the decision regarding his choice of location. We observed that most of the interest in physician distribution has been in its relation to economic factors. Research on other consequences has been meager, even in the United States where the bulk of research on the topic has been undertaken. Available evidence indicates that economic factors have only small effects on physician's choice of location and these are shown to be not the primary criteria deciding physicians' location. Consider, for instance, that of the 217 students who accepted bursaries during the first five years of the Ontario Programme for Underdoctered Areas, only 53% honoured their contracts, the remaining 47% committing themselves to repay their bursaries. In other words, as Joseph and Phillips (1984:78) have noted, "nearly one-half of a group that made an initial committment to take advantage of the financial incentives offered for practice in underserviced areas ended by trading off those incentives against other considerations" (see also Bass and Copeman, 1975).

The second approach focussing on the attributes of communities is found to be a commonly used approach in understanding the consequences of physician distribution. There have been several studies using the structural framework with regions, states, metropolitan areas, and counties as units of analysis. Findings consistently showed that predictors of physician distribution are population size, education, and race. Hospital facilities (measured by the number of hospital beds) are found to be predictors of specialist distribution.

The studies reviewed in this section are by no means exhaustive in terms of exploration of the factors which influence physician location and geographical distribution. Numerous studies not mentioned in the present review contain insightful and relevant information either directly or indirectly related to the topic and merit acknowledgement at this point. They include studies by Terris and Monk (1956); Parker et al. (1969); Anderson and Benham (1970); Brown (1972; 1974); Rosenthal (1978), Rosenberg (1980; 1983; 1984), and Wise and Zook (1983), to list a few. Readers are referred to Joseph and Phillips (1984) and Ernst and Yett (1985) for a review of the literature on the determinants of physicians location.

3.2.2 Canadian Literature

While not explicitly addressing the problem of physician distribution in terms of factors affecting it, some Canadian studies provide information that is of interest here. A brief review of such works is presented in this section.

In 1973, Enterline and his associates examined the effects of Medicare on the distribution of physicians' services among income and age groups and availability of services to the public, consumer satisfaction, and the health of the population. Upon examination of the data from two household surveys of 5790 and 5789 dwelling units each, and a physician survey covering the non-institutionalized population of the Montreal Metropolitan Area carried out before and after the introduction of Medicare in the province of Quebec, the authors observed that economic barriers were removed by Medicare, thereby increasing the utilization of physician services by persons in lower income groups. In addition, there was a shift in services from higher income to lower income groups. The authors also found that the removal of economic barriers to medical care had an effect in improving the general level of health of the population.

The results showed some dissatisfaction with the system among persons, particularly, in higher income groups as a result of long waiting times for appointments and in doctors' offices. While eight percent of the population surveyed considered the quality of medical care improved, 30% thought it worse. Among those who visited a doctor in the previous year, however, about 90% were satisfied with the services received. The same proportion was obtained in an earlier study conducted by these authors before the introduction of Medicare.

Bass and Copeman (1975), as part of an evaluation of programmes (physician subsidies, student bursaries, and community participation) designed to improve the distribution of physicians in Ontario, reported that "the programme for underserviced areas (physicians), in terms of its limited objective (placing more physicians in underserviced areas), has been successful (see Health and Welfare Canada, 1987 for a review of programmes that are designed to attract/retain students and physicians in rural and isolated areas in Canada). There has been a positive effect on the distribution of general practitioners in Northern Ontario" (p.407). According to the authors, of the 75 communities who built modern, attractive medical centres, almost all have been successful in obtaining physicians. In short, the results indicated that while financial incentives have helped, a big attraction in getting a doctor to an underserviced area is the presence of a new medical facility.

The impact of physician surplus on the distribution of physicians across Canada was the focus of a study by Roos and his colleagues (1976). More specifically, the authors addressed the following question: does a major increase (between 1968 and 1974) in the supply of physicians alleviate inequalities in the distribution of physicians across provinces or between urban and rural communities?

The findings indicated a reduction in disparities in physician supply across provinces as a result of a major increase in the supply of physicians in the country between 1968 and 1974. This, they claimed was due to the developments in two provinces: Newfoundland and British Columbia.

The impact of the increase on the urban-rural distribution was, however, not encouraging. They noted a more rapid fall in population-physician ratios in the rural areas than in urban areas in Manitoba, Alberta, and Saskatchewan, but, this was explained by population shifts from rural to urban areas rather than to physician movement. In Ontario, it was noted that the gap between the relatively disadvantaged north and the physician-rich south widened over the period 1961-1971.

The authors concluded:

> "Over the past decade, despite an unprecedented growth in the physician stock little progress towards equality in physician distribution has been made. Physicians have not flowed to the underdoctored areas rapidly enough and in some cases, not at all. This reflects on the effectiveness of national health insurance for automatically alleviating a country's physician distribution problems. It is sometimes assumed that universal medical coverage will attract more physicians to the underdoctored areas (LeClair, 1975). However, Canada's experience demonstrates that while universal coverage gives the underdoctored areas more money to spend on health services, it provides the same benefits to the overdoctored areas, and little fundamental shift in the distribution of physicians takes place." (Roos et al. 1976:187)

Northcott (1980) examined the distribution of physicians and dentists within census divisions, incorporated cities, towns, and villages in Alberta for the period 1956-1976 using the Gini coefficient. He found that the more specialized services including primary care physicians (interns, obstetricians, gynecologists, and pediatricians) were less equitably distributed than the more general services. The distribution patterns, in general, were relatively unchanged over the twenty years. However, there were indications of an equalizing trend in the distribution of primary care physicians and general surgeons.

The findings suggested that convergence trends are constrained by minimal population requirements necessary to support given types of services; these requirements are larger for the more specialized services. In addition, it was found that primary care physicians and dentists required larger populations in 1976 than they did in 1956. As a conclusion, the author suggested:

> "policies designed to redistribute medical personnel so as to reduce rural-urban disparities must recognize structural constraints. Failure to recognize constraining feautures will result in a futile swim upstream." (Northcott, 1980:21-22)

This section is concluded by reference to a recent study by Joseph and Bantock (1983) which examines the locational pattern of general practitioners within rural regions (Bruce and Grey) of Ontario for the period 1901-1981. Equating demand for general practitioner services with population size, and supply with the number of physicians, the overall demand and supply position at each time point 1901, 1921, 1941, 1961, and 1981 were analyzed by settlement type.

Two major findings emerged: First, the decline in the number of physicians parallels the decline in population size in the first half of the century but continues through to 1961 despite the upswing in population size. This resulted in an increase in the population/physician ratio in 1961. However, a substantial increase in the number of physicians was observed in the two counties between 1961 and 1981 partly due to province-wide developments. The results also indicated an increase in specialization. It is notable, however, that the levels of specialization in the rural area were considerably lower than in the province as a whole for the period under study.

Recently, Aizenman (1982), Moore (1982), Rosenberg (1979; 1984), and Gilmore (1985) have examined the geographic variation in physician distribution, again without providing evidence of structural factors affecting distribution. These studies have focused on either the provincial distribution of physicians or the micro-location behaviour of physicians. Aizenman, for example, noted (1982:1177) that:

> "Poor distribution of medical manpower, reduces the availability of physicians services in Canada... doctors are plentiful in cities and their suburbs but scarce in outlying areas. The increase in numbers of physicians has not improved this disparity since the increase is confined mainly to the cities."

As noted, this study neither considered the structural factors affecting physicians nor the characteristics or preferences of physicians in deciding their practice location. Northcott's study, however, holds constant population size while examining the distribution of physicians and dentists in Alberta. Researchers frequently address the problem of distribution, but fail to ask what causes (mal)distfibution. We need audacious studies, in both empirical and theoretical sense, which helps us account for and understand the major consequences of the physician distribution in this country.

3.3 Criticism of Structural Approach to Physician Distribution

Each of the studies reviewed, while providing unique insights, has severe limitations. It may be valuable to recode five of the major limitations that beset the work already undertaken in the area of physician distribution. A number of criticisms of the structural approach are discussed cogently by Anderson and Marshall (1974). For the most part, the discussion below is centered on these criticisms. It is not claimed here that every study contains at least one of these limitations or that any one study contains all of them. The limitations outlined below occur in most of the studies reviewed.

1. The theoretical framework

Even though some of the studies cited have been conducted within the framework of human ecology, this perspective has not been fully understood by some. The framework views the health care subsystem as one aspect of the way in which populations organize to deal with their environment. More specifically, as noted in Chapter 1, an important set of hypotheses concerns the causal interrelationships between the broad factors - demographic, and environmental/technological - and the various dimensions along which the health care subsystem is organized. In the ecological framework, variables both independent and dependent are attributes of aggregates and not of individuals. Failure to recognize this often leads to a misinterpretation of results.

In short, it is important to distinguish between the structural variables and those classified as 'individual' because the framework itself has explicitly dealt with the former. Therefore, the relationships of variables such as the presence of a medical school and the preference for large city living with the physician ratios should be interpreted keeping this aspect in mind.

2. Methodology

Another set of criticisms centres on the adequacy of the statistical techniques used. A method commonly used to study the structural dependents of physician distribution is regression analysis - a series of bivariate regression equations or a single multiple regression equation. While the method is sometimes appropriate to the problem in hand, given the present inadequate state of knowledge in some areas of physician distribution, it would seem useful to adopt a more revealing statistical technique such as a causal modelling approach. Specifically, use of regression techniques with description of only direct effects overlooks the possibility of important effects attributable to individual explanatory variables. In particular, much work is needed concerning the relative importance (if any) of education on physician distribution. For example, Elesh and Schollaert (1972) and Marden (1966) report on the basis of partial regression coefficients that certain variables such as education are unimportant in accounting for physician distribution and, in particular that of general practitioners and family physicians. These authors simply could not report the role of education on physician distribution through its effect on other intervening variables such as hospital beds. Where such effects (indirect) are excluded, the full effect of physician distribution is likely to be inaccurately estimated.

3. Substitution effect

Only two of the studies reviewed were concerned with the issue of so-called "substitution effects" (Reskin and Campbell, 1974; Anderson, 1977). Evidence based on these studies indicates interdependency among various categories of physicians. Reskin and Campbell (1974), for example, suggested that osteopaths as well as interns and residents may well provide functional alternatives to private practice physicians. Anderson (1977) reported that general practitioners were substituted for specialists in New Mexico counties where specialists were in short supply. It is important to consider such interdependencies because if there are substitute services that are reasonably efficient in providing the health care, then an increase in such services may help to reduce the overall expenditure on health.

4. Changes in physician distribution over time

A fourth major limitation of studies reviewed is their failure to examine the manner in which physician distribution changes over time (Exceptions to this statement are the works of Rushing and Wade (1973); Anderson (1977), and Northcott (1980)). Most studies make inferences concerning the impact of demographic and ecological processes on physician distribution on the basis of analysis of cross-sectional data. Cross-sectional data reveal structural relationships among variables at one point in time but do not clarify the manner in which change has occured (Anderson and Marshall, 1974). Moreover, such data yield no information concerning the variables that are responsible for change.

There can, of course, be no doubt regarding the importance of understanding how various factors contribute to change in the physician distribution over time and of considering their subsequent effects on physician distribution. Bass and Copeman (1975), for example, in their evaluation of programmes designed to attract physicians in rural northern Ontario, found that modern medical centres contributed a great deal in attracting physicians to these areas. In other words, change in one of the attributes of a community results in a change in the other.

5. Structural variables

While concentrating on such specific (often demographic) characteristics as age-sex composition, race and education, researchers have neglected other structural determinants of physician distribution such as, housing and geographic proximity to urban centres. Each of these variables will be briefly discussed here as an aid to interpreting their theoretical role in the analysis of physician distribution.

Proximity to a hospital is important to physician productivity, particularly to the specialist who spends most of his time in hospitals (Hambleton, 1971). Having a hospital close to his residence enables the physician to see many more clients in a day than he could otherwise. Based on these arguments, many have attempted to study the relationship between hospital and physician location (e.g., Fein, 1967; Hassinger, 1963). Hassinger (1963), for example, in examining a sample of rural general practitioners in Missouri found that distance from the nearest hospital is inversely related to the number of medical doctors located in an area. Of the total physicians, nearly two-thirds practiced within five miles of a hospital, while only one-sixth practiced twenty miles distant.

Simply stated, physicians need the facilities of a hospital and a laboratory for diagnosis and treatment of patients. Most small towns do not have these facilities. Consequently physicians tend to locate where such facilities are present. This undoubtedly results in a concentration of physicians where such facilities are available.

This line of reasoning may well be attributed to Hawley's notions regarding the 'friction of space' (Hawley, 1950). The concept, according to Hawley, involves the overcoming of a number of resistances to travel, which are described as either natural or man-made barriers, requiring the expenditure of time, energy, and money. It follows that as distance from a facility increases, resistance to travel increases and subsequently a tendency to locate near the facility increases.

Another area that appears worthy of separate and detailed attention relates to the current status of the (socio)economic approach for the understanding of the phenomenon of physician distribution. Researchers have given considerable attention to the influence of economic factors on physician distribution. Except for a few studies, research relating to physician location and geographic distribution to income differences has not shown a strong relationship.

In the author's view, one of the important weaknesses of the socio-economic approach to physician distribution is the general failure among researchers to consider other indicators of economic status. If higher income facilitates having more owner-occupied dwellings (single-family dwellings), physician distribution appears to be regarded as influenced by the number of owner occupied dwellings. For purposes of the discussion here, it is important to note that number of owner-occupied houses is an indicator of both social and economic status of an area. It certainly seems plausible that this variable may be more influential than such socio-economic factors as education or income. Some further aspects of this particular variable will be discussed, more appropriately, in the final section of this chapter.

Another limitation of current literature involves the dimension along which the dependent variable is measured. Some studies have used total number of physicians as the dependent variable (e.g., Marden, 1966; Reskin and Campbell, 1974); others have used the ratio of physicians to population (e.g., Rushing and Wade, 1973; Anderson, 1977). It has been argued that the physician-population ratio is superior to the absolute number in that it permits direct control for population size (Anderson and Marshall, 1974). Any analysis that does not take this into account may result in misleading conclusions because it has been widely recognized that a significant relationship exists between population size and physician supply.

Although interest in the structural approach to physician distribution has increased markedly in recent years, the details of precisely which factors are responsible for physician distribution lie outside the scope of most research carried out to date. A better understanding of the determinants of physician distribution and changes in physician distribution is essential if effective policy to redistribute physicians is to be made possible. The structural approach offers the promise of facilitating the understanding of physician distribution trends and of providing policy alternatives (some further aspects of the ecological approach will be discussed in the next session). What is needed now are studies capable of exploiting the human ecology framework for providing a new and enlightened view of causes of physician distribution. The present study, by taking into account some of the limitations of the current literature, is intended as a pioneering effort towards this goal.

3.4. The Ecological View of Physician Distribution

Physician distribution may be defined as either an individual or an aggregate phenomenon. Viewed as an individual phenomenon, the focus tends to be on individual physicians rather than on the aggregate. This leads to arguments made earlier that physician distribution can be explained by reference to the characteristics, values, and motives of physicians. Accordingly, physicians choose to practice in a particular location because of reasons such as higher aspirations for upward mobility. While it is legitimate to approach physician distribution from this "individual approach", one must realize that personal preferences and motives are themselves part of the actual behavior, and as such, should be explained in terms of social structure.

Ecologically, physician distribution may be viewed as a response to areal population and environmental/technological changes. When physician distribution is viewed in this perspective, the important question becomes whether it increases or decreases disparity, what the size of the physician change is in relation to changes in other structural factors.

Hawley (1967) has argued, in his classical study, that all changes in a population's functioning organization result from changes in the environment or technology. Applying this proposition, physician distribution should be viewed as a response to changes in population, environment or technology. Thus, variations in the physician ratios can be explained by observing the effects of variations in the demographic and environmental and/or technological factors, and we assume that the latter takes a mediating role. That is, a prerequisite for the functioning of institutionalized services is its environment/technology. Sly (1972:617) has provided us with a simple example to understand how changes in environment/technology results in a population's activities (E→O):

> "If there is no iron, there can be no extraction, production, and distribution of steel. Likewise, there can be no steel plow (E→T); and agricultural organization will be restricted to small selected plots of cultivated land (E→T→O). Furthermore, restricted land cultivation influences the size of the population which can be supported (E→T→O→P)."

The relevant message is that the broader concepts of interest to human ecology, namely, Population (P), Environment (E), Technology (T), and Organization (O) are interdependent and may be causally linked.

Sly's example is helpul in testing our proposition that the causes of environmental/technological change can be found in a population's demographic, socio-economic (including cultural), and ecological conditions. Furthermore, physician distribution is a response to changes in environmental/technological conditions.

Schematically, and ecologically these propositions are illustrated in Figure 3.5-1.

3.5 Development of Hypotheses

Given an understanding of the factors influencing physician distribution, we can turn to the formulation of hypotheses which are suggested by the general interests of human ecology and the findings of empirical investigations. In this section a causal model of physician distribution is presented with special attention paid to the ways in which demographic; socio-economic (including cultural), ecological, and environmental/technological factors might affect the physician distribution. The model to be analyzed possesses two features that set it apart from other models current in the literature on physician distribution.

In the majority of models currently typifying the literature, physician distribution is characterized as the result of a direct consequence of demographic, socio-economic, and environmental factors. The model developed in this study provides an alternative view in which demographic, socio-economic, and ecological factors may be taken as influencing the environmental factor. In this way, the former set of variables may exert an indirect influence upon physician distribution.

The second distinguishing feature of the model is the explicit attempt, detailed in the foregoing section, to include consideration of the structural factors, 'geographical proximity to nearest metropolitan area' and 'owner-occupied dwellings' that influence the environmental factor and hence the physician distribution.

The theoretical and empirical works all indicate the appropriatness of causal structures and lead to the central thesis of this dissertation: namely, that *differences in the distribution of physicians are best viewed as an outcome of environmental conditions within the area, subject to certain demographic (including population size), socio-economic (including cultural), and ecological constraints.*

The central hypothesis is illustrated in Figure 3.5-1. As implied earlier, focussing on organizational structure of physicians, a causal model is developed which suggests that demographic, socio-economic, and ecological factors affect environmental/technological factors directly; their effects on physician distribution is produced through changes in environmental/technological factors. The ultimate dependent variable of interest is the physician variable. It is assumed that the initial factors affecting the physician variable are population size, age-sex composition of the population, education of

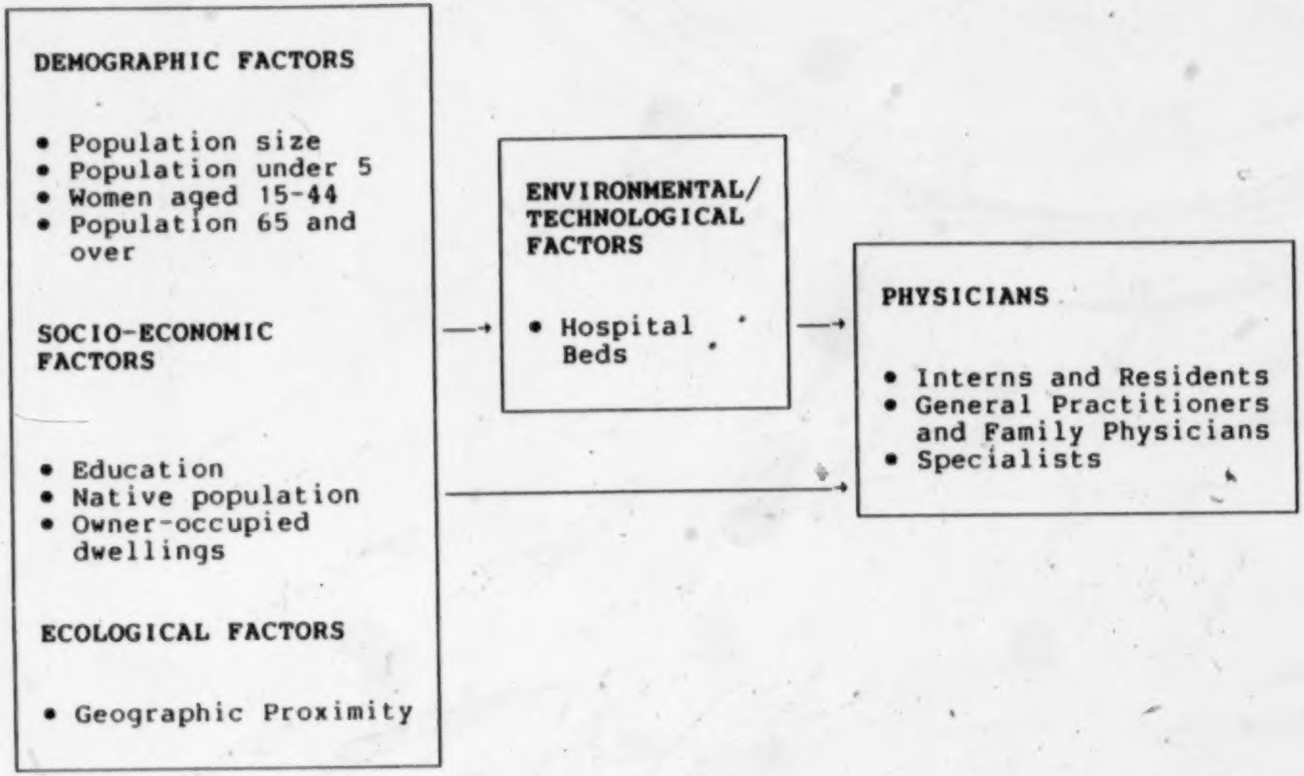

DEMOGRAPHIC FACTORS
• Population size
• Population under 5
• Women aged 15-44
• Population 65 and over
SOCIO-ECONOMIC FACTORS
• Education
• Native population
• Owner-occupied dwellings
ECOLOGICAL FACTORS
• Geographic Proximity
ENVIRONMENTAL/ TECHNOLOGICAL FACTORS
• Hospital Beds
PHYSICIANS
• Interns and Residents
• General Practitioners and Family Physicians
• Specialists

Figure 3.5-1. Schematic Diagram of the Determinants of Physician Distribution

the population, population native, owner-occupied dwellings, and geographic proximity to the nearest metropolitan area. Most of these variables are expected to have an indirect impact through another variable, hospital beds. Of course, the model does not include all measures of environmental factors. Unfortunately, we lack the information necessary to model all macro-level effects of environmental conditions. In the absence of other intervening variables, some associations are modelled as direct effects. Although possible reciprocal effects between variables are suggested, the essential patterns of influence are thought to follow the directions as diagrammed. Also, the model assumes the interrelationship among the initial set of variables.

Specific hypothesis for variables included in the model are presented below:

Hospital beds

The importance of hospital facilities in explaining physician distribution is suggested by various studies (e.g., Marden, 1966; Reskin and Campbell, 1974; Anderson, 1977). These works demonstrate that a greater supply of hospital beds within a community largely explains the tendency of physicians to be found there. This pattern is more often found for specialists than for general practitioners.

One explanation is that good hospital facilities lead to a greater demand for physician services, which in turn will necessitate a greater supply of physicians. In so far as physicians require the use of hospital facilities and spend a substantial amount of their time within hospitals, it may also be regarded as a prerequisite for attracting physicians. Feldstein has noted that "the physician will substitute beds for his own time in treating the patient because he can see more patients in a given time" (1966:155). If this is true, they will locate close to hospitals to reduce travel time. Drawing on these arguments, we hypothesize *a positive relationship between hospital beds and physicians.*

Population size

Previous research has suggested that different types of institutions/institutionalized services display considerable differentiation in their response to variations in population size (e.g., Hawley, 1941; Marden, 1966; Reskin and Campbell, 1974; Northcott, 1980). It may be argued that institutions of any kind require a certain level of population; medical services provided by physicians is one among them. *A positive association is expected between population size of an area and physician* *distribution*. Moreover, this relationship is expected to hold for various categories of physicians.

Hospital facilities should also relate to population size; *the higher the population size the greater the number of hospital beds available in an area.*

Age-sex composition

A common hypothesis in the literature on physician distribution is that age-sex composition of the population relates to the physician supply (Marden, 1966; Reskin and Campbell, 1974). As individuals age, incidence of chronic illness increases; chronic diseases become more frequent causes of death. Similarly, the young population experiences a high incidence of acute infectious diseases. In considering the differential utilization of health care services between men and women, women in their child bearing years use more medical care facilities than their counterparts. Based on these arguments, it is hypothesized that *if the greatest need for medical care occurs in the three age-sex groups - population under 5 years of age, women in the age group 15-44, and population 65 years and older -- then areas in which they predominate should have proportionately higher number of physicians than areas in which the three age-sex groups are under-represented.*

For the same reasons, *the availability of hospital facilities (hospital beds) is positively related to age-sex composition of the population.*

One might argue that population aged 75/80 and older may be a more sensitive indicator of the need for health services, than population aged 65^+. However, population aged 65 and older is preferred in this study mainly because the morbidity rates are higher among population aged 65^+ (Statistics Canada, 1988). Therefore by considering the population aged 75/80 and older, we would be underestimating the need for health services. It should also be noted that the life expectancy is considerably lower among males (as of 1983-85, the figures are 72.9 and 79.8 respectively for males and females). Be it as it may, it is the nature of age distribution that census division with large proportion of 65+ is the same as census division wiith large proportion of 75/80+. So it does not matter which indicator is chosen, by and large, the same census division responds to it.

It is realized that economic old age dependency ratio (ratio of economically inactive elderly people to the economically active of all ages) would be a more sensitive indicator of the local finance base than the demographic old age dependency ratio or the proportion of elderly population. It would indicate not only the demand for medical services, but also the economic base for financing such services at the local level, independently of some of the financing that comes from federal treasuries. However, due to unavailability of data at the census division level, economic old age dependency ratios can not be calculated.

Education

There are two reasons for expecting education of the population to affect physician distribution. In part this association is believed to arise because highly educated persons are likely to know more about the availability of medical services as well as the benefits that could be achieved by their consumption of such services. They are also better able to purchase medical care and have greater access to information about good health practices. In particular, there is evidence of considerable social class differentials in the use of preventive health services (Waddington, 1977). In most studies, lower social class (as measured by education and occupation) persons are found to receive less health information and promotive care such as ante- and post-natal care (McKinlay, 1970; Brotherston, 1976).

McKinlay (1972) points out that there are a number examples of economic barriers to the receipt of care in a fee-for-service system. In particular, high costs of medical care and low incomes appear to force some to change their venues of health care (Joseph and Phillips, 1984). In a study in Oklahoma City, for example, the elderly were found mostly attending hospital emergency rooms and outpatient departments for primary care due to the cost of private physicians (Bohland and French, 1982). In countries such as Canada, which have a fee-for-service system, economic barriers to utilization of services should be limited to the costs of transport to service and insurance status. In Australia, Goldstein (1982) has noted that prior to the Medibank experiment in 1975, between 10 and 15 percent of the population were not insured, most of them were drawn from low-income groups and were discouraged from taking up insurance by frequent rises in premium. Therefore, it is quite possible that income affects (under)utilization. In other words, lower income regions are likely to be poorly provided with medical services and this may cause lower levels of utilization.

Income may be an important variable (although closely allied to education), but one which is rarely included in macro analyses of physician distribution and one which does not seem to exert a considerable influence on physician supply. For example, Elesh and Schollaert (1972) found that education of the population had greater influence on physician distribution than market area income. Furthermore, there should be a high positive relationship between educational status of the population and income per capita. Those areas with larger percentages of educated persons are more likely to have larger per capita incomes, since they are more likely to have larger percentages of their population in high-status occupations. In multivariate analysis, inclusion of both educational status of the population and per capita income in the same equation could give distorted estimates of the regression coefficients. In this study educational status of the population is used in preference to income per capita on the grounds that it will more accurately capture the potential demands for medical services than per capita income. We would expect *educational level of the population to be positively related to physician distribution.*

Education is also associated with the availabilty of hospital facilities. It is expected that, the higher *the educational level of the population in an area, the greater the hospital. facilities such as hospital beds to support health care personnel.*

Native population

The model assumes a link between ethnic composition of the population and physician distribution. There is no empirical evidence to support the argument that utilization of health services among the native people (Indians, Inuit, and Metis) is less than the rest of the population. However, there is reason to suspect that the native population is at a disadvantage with regard to both knowledge and access to medical care services.

The relatively low health status of the native people with an expectation of life at birth of 62.4 years[3] may probably be due to insufficient number of native physicians to provide medical services. The social and cultural differences between the native people and health care professionals is believed to be an important factor that deters them from seeking care. This argument is echoed in a number of reports which stressed the importance of involving indigenous people in the delivery of health care services (e.g., Berger, 1980). One could argue that in the long run a community can probably increase its native physicians and reduce the social distance between the consumers and the providers of health care and thus improve the health status of the native people. It is argued here that, *so long as cultural barriers exist, it is quite likely that physicians will be* *fewer in areas where a large proportion of the population is 'native'.*

Ethnic composition of the population has also got implications for the environmental factor - hospital beds. *An area in which a large proportion of the population is 'native' should be characterized by smaller number of hospital beds.*

Owner-occupied dwellings

Another principal variable affecting physician distribution is the number of owner-occupied dwellings in an area. As a reflection of an area's socio-economic status, the availability of owner-occupied dwellings seems likely to predict greater physician supply. To the extent that greater numbers of owner-occupied dwellings reflect higher economy, number of available owner-occupied dwellings should also be associated with a better supply of hospital facilities (i.e., hospital beds). However, Robertson (1970) drew quite different conclusions in studying census tract data on physicians in Boston. He found that physicians tend to concentrate in areas characteristically high in a factor identified with low owner-occupied housing and low median income. Robertson concluded that in Boston between 1940 and 1960, medical practice had become more specialized and physicians had clustered into a few locales that were characterized by office buildings and proximity to hospitals. Knox's study is in accord with Robertson's conclusions. In a study of primary care physicians in four Scotish cities, Knox (1978) observed that surgeons were found absent in newer owner-occupied housing estates and concentrated in deprived inner-city areas. However, Knox raised the cautionary note that generalization from his brief examination of only four cities is dangerous. While it can be argued that large commercial centres tend to have heavy concentration of physicians, it can also be argued that physicians seek office locations near expensive residential areas so as to minimize their own travel to the office (Lave et al. 1982). According to these interpretations, the effect of owner-occupied dwellings on physician distribution appears unclear. However, based on evidence from this author's study, it seems reasonable to expect a positive effect of owner-occupied dwellings on physician distribution (see Krishnan, 1983).

Another perspective on the relationship between housing and physician distribution is represented by this author's study (1983) of the importance of housing characteristics on physician distribution in Canada. The author argued that the presence of poor quality housing in an area (measured by the number of houses in need of major repair) deters physicians in seeking a location to set up practice. In other words, physicians are particularly apt to locate in areas where there are high quality homes. In general, the presence of good housing makes an area more attractive to people high in the social scale, thus resulting in segregation of the higher classes. This variable, however, was not included in the present study because of nonavailability of data for 1971.

We might summarize by stating that there are regional differences in the level of home ownership with lower levels in economically poor areas and higher levels in economically rich areas. These differences should relate to hospital facilities and physician distribution. More specifically, we expect a *positive effect of owner-occupied dwellings on hospital beds and a positive effect on physicians supply.*

Geographic proximity.

Two main approaches regarding regional accessibility appear in the literature.

Knox (1978) developed his measure of accessibility based upon the gravity approach in the context of research into intraurban variability in access to general practitioners in Britain. Knox calculated nodel accessibility, representing urban neighbourhoods using the formula:

$$A_i = \sum_{j=1}^{n} \frac{(S_j)}{D_{ij}^{k}} \qquad (3.5\text{-}1)$$

where:

A_i = accessibility in neighbourhood i;

S_j = size of surgery facilities in neighbourhood j;

D_{ij} = linear distance between the geometric centres of neighbourhoods i and j;

k = distance decay function

S_j was measured in terms of the total number of hours of consultation time available in a specific neighbourhood and k was chosen as a negative exponential function ($e^{-1.52D}$).

The estimate of neighbourhood accessibility (equation 3.5-1) was modified by incorporating measures of the mobility of residents of the various neighbourhoods, with levels of car ownership in neighbourhoods (C_i) - a surrogate measure of relative accessibility.

$$A_i(t) = C_i \frac{(A_i)}{T_c} + (100 - C_i) \frac{(A_i)}{T_p} \qquad (3.5\text{-}2)$$

where:

$A_i(t)$ = time-based index of accessibility for neighbourhood i (a measure of potential accessibility of neighbourhood)

T_c/T_p = average time taken to travel a unit distance from the geometric centres of neighbourhood by car (T_c) and public transport (T_p)

The measure was then weighted in terms of the population potential (M_i) of each neighbourhood to account for differences in population,

$$M_i = \sum_{j=1}^{n} \frac{(P_j)}{D_{ij}{}^k} \tag{3.5-3}$$

where:

P_j = population of neighbourhood j

The final index of accessibility (I_i) was computed as:

$$I_i = \frac{A_i(t)[\%]}{M_i[\%]} \tag{3.5-4}$$

Values exceeding 100 indicate a relative overprovision of general practitioners in a neighbourhood, whereas values below 100 indicate a relative underprovision.

The Knox measure is, on the whole quite sophisticated, including a time-based measure of the supply of general practitioners services and a factor representing the differential mobility of neighbourhood populations (Joseph and Phillips, 1984). As noted by Joseph and Phillips (1984), the measure has certain limitations as well (see also Knox, 1978). First, there is the possibility for movement across the boundary of the system (that is, people outside the i neighbourhood may use services within and, similarly, people in i neighbourhood may use services located outside the i neighbourhood). Second, the index provides only "an average measure of accessibility, whereas in reality some important variables in accessibility will inevitably occur as a result of true-geographic constraints inherent to different sociospatial classes..." (Knox, 1978:426). According to Knox, the measure could be made more sensitive by the inclusion of variables such as age structure, morbidity, and mortality as indicators of comparative need.

Another major problem associated with the measure is the identification of appropriate distance decay function. In his measure, Knox (1978) used a negative exponential function based on patient registration data derived from a study of one suburban Liverpool practice. However, the generality and transferability of it is problematic in the absence of other comparable data (Joseph and Phillips, 1984). In Barnett's (1981:34) words:

> "The validity of including such (distance decay) exponents in gravity or potential type models is often confounded by their variability, that is, the extent to which the distance decay pattern of

> patient-doctor contacts is similar for different parts of the city. If the shape of the contact fields is significantly different between doctor-rich and doctor-poor areas, for example, then the inclusion of a general exponential value may be questionable."

Joseph and Bantock (1982) developed their measure of regional accessibility in an intraregional context. Like the Knox (1978) measure, the nodel accessibility was calculated as:

$$A_i = \sum_j \frac{GP_j}{d_{ij}^{\,b}} \qquad (3.5\text{-}5)$$

where:

A_i = potential physical accessibility of rural enumeration area i to general practitioners;

GP_j = general practitioners at j within the range of area i;

d_{ij} = distance between i and j;

b = exponent on distance

The nodel accessibility was then modified incorporating the impact of catchment populations on the potential availability of physician services.

$$D_i = \sum_j \frac{(P_j)}{D_{ij}^{\,b}} \qquad (3.5\text{-}6)$$

where the potential demand on a doctor at j (D_j) is a function of the magnitude of the population within the range of the service offered (that is, within the doctors' catchment area), modified by their distance away. The final measure - potential accessibility of general practitioner service to individuals - incorporating a weighted estimate of physician availability was computed as:

$$A_i = \sum_j \frac{GP_j/D_j}{d_{ij}^{\,b}} \qquad (3.5\text{-}7)$$

The measure was evaluated through a case study in Wellington County, Southern Ontario, Canada. Physicians located outside the study area but known to take patients from the study area were included in the analysis and the catchment population of these physicians was calculated using equation 3.5-6 above, thus circumventing the boundary problem.

The accessibility index was calculated for three ranges of (services) values (5, 10, and 15 miles), with the distance exponent fixed at -2.0. The problem of finding an appropriate distance decay function, in the absence of studies of utilization in comparable areas, still remains.

In summary, a major limitation of the regional accessibility measures, as noted by Joseph and Phillips (1984) is that they are complex and demanding in their inputs. Accessibility measures require the specification of the distance decay function as well as the location of supply and demand. Such specifications are not available in our data set, thus no simple and reliable measure of regional accessibility can be computed.

We now turn to consider a less complex spatial variable (geographic proximity) which might act as an important correlate for the geographically oriented models considered in the present study. More specifically, this study employs a distance measure (distance of a census division from the nearest metropolitan area), which is a crude measure for accessibility of health facilities, but will serve as adequate control for an area's position within a metropolitan area. In order to measure distance, Hodgson (1984) uses the simplest method, one based on 'great circle distance'. We will come to Hodgson's measure later in this chapter.

There is a tendency among people to concentrate in and around the metropolis and such a tendency may be more pronounced in the case of an urban population (Bogue, 1950). As Hawley (1950:238) argued, "the focal point on the territorial organization of the community is its centre, for it is there that interdependencies are integrated and administered." It follows that areas on the periphery of a metropolitan system tend to be less specialized in function than areas near the centre. Hawley's views are particularly instructive here:

> "Population tends to distribute itself in relation to job opportunities, evacuating areas of diminishing opportunities and gravitating to areas of increasing opportunities." (Hawley, 1950:167-168)

One thus arrives at the proposition that the presence of a service facility depends upon an area's metropolitan position. Therefore, treating physician services as dependent and geographical proximity to the nearest metropolitan area as independent, one can hypothesize that *differences in physician distribution will serve as a function of differentials in proximity to the nearest metropolitan area*, to the extent that physicians prefer to practice in large metropolitan areas rather than in remote areas. It should be obvious that geographic proximity is related to hospital facilities: *the greater the distance of an area from a metropolitan area, the fewer the hospital beds.*

Of the variables described above, it will be evident that owner-occupied dwellings, education, ethnic composition, and age-sex composition can vary considerably from one part of the country to another. Therefore, even these apparently aspatial characteristics may, in their distribution, acquire important spatial significance.

The last set of independent variables consists of nine dummy variables representing the provinces. As discussed earlier, methods of organizing, financing, and administering health insurance plans vary from province to province (see also section 4.2). Thus, province as a variable may account for variation in physician-population ratios, in spite of the equalizing influence of federal policies. To ascertain whether province influences variations in physician availability, an additional analysis was performed. The regression analyses reported herein were replicated with nine additional variables (provinces coded as nine dummy variables, Ontario being the reference category). Relevant results are presented in Appendix D.[4]

We have not included the nine variables in our structural equation models because the major purpose of this thesis is to document spatial patterns and trends in physician distribution in the context of socio-demographic and environmental change and because an excessive number of independent variables relative to the number of observations (ranges from 59 to 217) distorts the estimates of the coefficients. Another argument for not including them is that they are exogenous rather than endogenous variables in the physician distribution models. Consequently it is statistically problematic simply to include them in the structural equation models.

The preceding discussion of some geographic determinants of physician distribution has, because of limited scope of this thesis, omitted or glossed over some important factors. These include income (for which education and owner-occupied dwellings are surrogate measures), urbanization, and number of medical schools. The selection of variables is somewhat arbitary but reflects their apparent importance at present.

The above hypotheses are tested within the same framework in order to examine the causes of change in physician distribution over the period 1971-1981.

CHAPTER 4

DATA AND METHODOLOGY

The discussion below is organized as follows. First, different sources of physician data - noting the strengths and weaknesses of each - are briefly described. The second section of the chapter focuses on the description of variables: endogenous and exogenous variables are outlined and the dimensions along which the variables being measured are described. This is followed by a fuller discussion of the statistical procedures used to test the hypotheses generated in Chapter 3. The discussion includes the fundamentals of LISREL-type causal modelling and the features of the LISREL VI computer program.

4.1 Source of Data

Reliable data on physician manpower in Canada are difficult to obtain and this may be the reason why the subject of physician distribution has received so little attention. Three different sources of information on physician manpower are available:

(1) data from Revenue Canada, Taxation;

(2) data from the Sales Management Systems (SMS) tapes;

and

(3) data from individual provinces.

Each of these has its own strengths and weaknesses and Roos and her colleagues (1976) have identified them. Nevertheless, it should prove useful to review selectively the major limitations noted by these authors in understanding the quality of the data set utilized for the present study.

The data from Revenue Canada, Taxation are cleaned and modified by the Health Economics and Statistics section of the Department of National Health and Welfare, Canada. The physician counts include 'active fee practice physician', defined as a 'physician whose main source of income was in the form of fee payment for personal medical services' and/or 'whose main employment was the provision of such services'. As Roos and her colleagues have noted, this is probably the best measure of physician manpower involved in direct patient care. However, the data are not without limitations. First and foremost, there is coding inaccuracy and the complex sampling framework employed to gather information makes it difficult to have an accurate physician count by preventing an extensive check of coding accuracy. Secondly, the framework underwent a substantial change in 1973, thus making time series analysis difficult.

The Medical Section, Circulation Department, Southam Communications Limited (MSCD-SC) in Ontario maintains a physician card file and a physician computer tape file, both of which are utilized primarily for commercial mailing purposes. The card file includes practically every physician in Canada. The minimum information on a card is the physicians' name. When additional information about the individual physician is obtained, the MSCD-SC produces a computer record, a combination of descriptive data (name and address), and coded information. The coded information includes: province, county, and municipality of residence; type of physician (general practitioner, specialist, intern, resident); certified specialties (up to a maximum of four); primary interest; appointment (part-time or full-time, no appointment, medical research, teaching, administration, director, etc.); university or country of graduation; year of graduation; activity status (active, removed, deceased, abroad, retired, military, not - in - private - practice); registration status (registered or not registered); the hospital of affiliation; and physician identification number (physicians are assigned permanent and unique numbers).

The information on physicians is collected from different sources including hospitals, provincial registrars, the Medical Council of Canada, the Royal

College of Physicians and Surgeons of Canada, the provincial medical associations, pharmaceutical companies, and La Corporation Professionnelle des Medicins du Quebec. A copy of the computer tape is purchased four times a year by the Health Programmes Branch of the Department of National Health and Welfare through arrangements with Sales Management Systems (SMS), a division of Southam Communications Limited. On the tape provided to the Health Programmes Branch, only those physicians with known and correct (as determined by mail returns) addresses are included. A "check letter" which consists of a questionnaire is sent out by MSCD-SC to a physician if further information is desired or if only his name and address are known. City directories, telephone directories, news papers, and journals provide clues to changes which may require a follow-up "check letter". Also, the Health Programmes Branch limits its analysis to only those physicians who designate themselves as 'active' or 'not-in-private-practice'.

It is generally acknowledged that the SMS data on interns and residents are weak. This is so because these physicians are highly mobile and it is difficult to obtain their addresses accurately at one point in time. If these two groups of physicians are excluded, the SMS data appear to be quite reliable (we will come to the reasons for including intern and resident physicians in our study later in this section). A primary benefit of the SMS data over the other two data sets is that (beginning December 31, 1978) the area codes on the tape are designed to coincide with Statistics Canada's geographic codes, for which population data are available.

Each province has its own system for obtaining physician counts. British Columbia and Quebec, for example, have developed sophisticated computerized systems. Other provinces, in cooperation with Statistics Canada, have developed a data-base on physicians. Each province has, perhaps the best information on its physicians, particularly on the intra-provincial distribution. The use of provincial data for a national study of physicians is, however, found inadvisable for two main reasons: (1) definition of physician varies markedly from province to province; and (2) physicians simultaneously registered in two or more provinces may be double-counted.

A major conclusion reached on the basis of the foregoing discussion is that the SMS data, in some instances are superior to the other two, particularly, when a national analysis of physician distribution is required. The data permit one to examine the relationships between the distribution of physicians and other demographic and socio-economic data, since both data are available by geo-political units: the census divisions.

The basic data for the present study are contained in a computer printout prepared by the Health Programmes Branch using the SMS tapes. These printouts provide information on physicians as of December 31, 1970 and 1981 (Health and Welfare Canada, 1970; 1981a). The geographic locations, however, are based on the 1966 and 1976 census classifications. The physician counts include all known 'active' and 'not-in-private-practice' physicians by type of practice (interns, residents, general practitioners or family physicians, and specialists) and by place of location (census division, census metropolitan area or census agglomeration, and province), but exclude 'removed', 'abroad', 'military', 'retired', and 'deceased' physicians.

It is realized that the inclusion of intern and resident physicians in the analysis could possibly create random error. However, at least in those provinces where these physicians provide a good amount of medical services, it is possible that their exclusion may lead to under-estimating the services available to the public. Besides, as is the case with general(family) practitioners or specialists, interns and residents are unevenly distributed across regions. It is therefore decided to include interns and residents in the analysis by treating them as a seperate category. It is also realized that more accurate information of direct patient care will be attained by excluding the 'not-in-private-practice' physicians. This, however, is difficult, since the Health Programmes Branch has noticed that this designation has not had uniform meaning over time. Because physicians are not given a clear definition of the title, they decide by themselves whether or not the question on 'not-in-private-practice' applies to their own situations.

As earlier noted, data on physician manpower have been coded to census divisions by Health Programmes Branch of Health and Welfare Canada. Although the data-base is remarkably complete, particularly since 1971 and the best available, for the current research, there is no information on the biases and errors, random or non-random, with which the coding has been carried out. It is not known, neither here nor in the central coding agency, whether the physician addresses were hospitals or offices or homes, probably all three. In fact, a typical physician has a home, has hospital privilages and a separate office, but only one has been coded, namely the one that was on the list.

Whatever the address coded, the matter is further compounded by the boundaries of census divisions. It is possible for a physician to receive his/her professional mail at an address in one census division and have his/her patients commute to the office from other census divisions. This problem is attenuated by the large size of the census division and would be more severe in smaller areas, such as census tracts, if coding was done to census tracts. The errors may tend to cancel each other and, in any event, it is a limitation of the data which could not be resolved in the time and within the resources available for this study. The question of boundaries and their role in aggregation has not arisen for the first time in this research. It received treatment and evaluation by many writers (e.g., Joseph and Phillips, 1984).

It is to note, however, that the reliability of inferences produced by analysis depends primarily upon the size of the sample. The adequancy of sample size is related to the level of aggregation used, in terms of space. Data sets of this sort which assign individuals to areas for the purposes of obtaining areal supply of physicians obviously involves some aggregation of space (i.e., aggregation beyond the level at which the data are reported). This might involve the aggregation of areal units by arbitarily assigning physicians to some areas. In view of the fact that smaller areal units are particularly sensitive to the dangers of spatial aggregation, we favoured larger areal units such as census divisions rather than smaller units such as census subdivisions (we will come to this point later in this chapter). That is, if the study area was divided into too many subareas, the possibility of obtaining spurious results would be increased. To put it differently, "the reliability of samples decreases with increasing disaggregation, so does the insights produced by analysis" (Joseph and Phillips, 1984:155).

Data on hospital beds are obtained using the List of Canadian Hospitals and Special Care Facilities, Place Name Reference List and the Census Division Maps of individual provinces, all published by Statistics Canada (Dominion Bureau of Statistics, 1971; Statistics Canada, 1971e; 1981d; 1981e; 1981f; 1981g; 1981h). The List of Canadian Hospitals and Special Care Facilities provides information on hospital beds and cribs by municipality or place location of hospitals. For the purpose of this study, these hospitals are assigned to appropriate census divisions by the use of Place Name Reference List and/or Census Division Maps (Statistics Canada, 1971e; 1981e; 1981f; 1981g; 1981h).

Data on population size, age-sex composition, education, native population, and owner-occupied dwellings are obtained from the Canadian Census Reports of 1971 and

1981 (Statistics Canada, 1971a; 1971b; 1971c; 1971d; 1971f; 1981a; 1981b). Finally, data required for computation of geographic proximity to the nearest metropolitan area (i.e., latitudes and longitudes) are obtained from the Place Name Reference Lists (Statistics Canada, 1971e; 1981e; 1981f; 1981g; 1981h). The computation of the variable will be discussed in section 4.3.

4.2 Analysis of Physician Distribution: The Census Division Scale

In Canada, methods of organizing, financing, and administering health insurance plans vary across provinces. The Canadian health system thus comprises ten systems. Each province is free to determine how its share of health care cost will be financed. Most provinces finance their share from general revenue, while Ontario, Alberta, British Columbia, and Yukon impose premiums. Premium assistance is available for some residents with limited income, and premium exemption is provided in Alberta and Ontario for those over 65 years of age (Statistics Canada, 1988).

Arrangements for delivery of medical services and payment of physicians also vary across provinces. Most physicians are paid on a fee-for-service basis. Other arrangements include salary, capitation and monetary incentives to practice in underserviced areas. The administrative responsibilities for health care services are often fragmented, ~~so that~~ better co-ordination is essential for better planning. In other words, administrative collaboration at a small spatial scale is a crucial requirement if effective spatial planning is to be developed.

In addition, small area planning may help to overcome a lack of conformity between national or provincial health planning which are relatively well developed as compared to local planning (Grime and Whitelegg, 1982). "Most of the crucial inequalities in health are actually caused by local physical inaccessibility" (Joseph and Phillips, 1984:179), so as a starting point in the search to identify factors responsible for inequality, small areas are preferred units of analysis. It is at the local level that the reality of supply and demand meet and, therefore, this is the level at which detailed health care planning must make sense of broad national/provincial objectives (Joseph and Phillips, 1984).

At a high level of aggregation, a regional availability measure could possibly mask important subregional variations (Shannon et al. 1969). At the provincial level in Canada, for instance, ratios of population per physician would mask important intraprovincial variations. Even at less aggregate levels such as census divisions or census tracts, regional availability measures are likely to be too crude to detect and monitor the significance and impact of changes in the organization of physician services (Joseph and Phillips, 1984).

The problem of intraregional variability can obviously be minimized by the use of less aggregated spatial units. However, as Joseph and Phillips (1984:100) have noted, "this gain has to be traded off against the increasing problem of permeability (cross-boundary utilization flows)." The work of Spaulding and Spitzer (1972) points to this fact. As part of an analysis of medical manpower trends in Ontario during the 1960s, the authors compared the population-primary physician ratios of urban and rural areas. In a number of instances, they found the ratio to be much higher in the rural regions in comparison to urban cores. In the case of Kingston, a city with a population of about 60,000, the ratio in 1971 was 1040:1 whereas in the remainder of Frontenac county (within which Kingston is located) the ratio was in excess of 4300:1. There might have been a substantial difference in the potential physical accessibility of general practitioner services in Kingston and Frontenac in 1971 but it is unlikely that it was as marked as suggested by the ratios, mainly because residents of Frontenac county who are near to Kingston had access to general practitioners in Kingston (see Joseph and Phillips, 1984). Given these problems, it may well be impossible completely to overcome the scale problems in physician supply research.

The availability of data on physicians and the characteristics of the population by census division resulted in the decision to use census divisions as the unit of analysis. In conducting cause-effect relationships it is essential to have our variables derived from data sets which are compatible in time and space in order to avoid spurious relationships. Some census divisions in 1966/71 were divided in the 1976/81 census or have had their boundaries changed. In such a situation, two choices for research strategy have been put forward: either to maintain constant boundaries or to use actual boundaries in each census year (Balakrishnan and Jarvis, 1975). The present study adopts the former of the two since it is a study involving changes in physician distribution over time. It is the author's contention that this procedure will not result in a markedly underbounded area since the changes are not very crucial. Accordingly, the 260 census divisions for which physician data are available in 1981 are combined into 232 census divisions in 1971.

4.3 Description of Variables

This section provides brief descriptions of the variables used in the analysis. In all, twelve variables (excluding the nine provincial dummy variables) are used. These are defined as follows:

Physicians

Physician variables included in the model are: the number of interns and residents per 100,000 population (IRP), the number of general(family) practitioners per 100,000 population (GFP), and the number of specialists per 100,000 population (SPP).

Hospital beds

Hospital beds (BED) is measured by the number of general hospital beds and cribs per 10,000 population in a census division.

The physician(bed)-population ratios may be viewed as a physician(bed) availability index, adjusted by the relative numbers of support populations.

Population size

Population size (POP) refers to the total population of the census division in millions.

Age-sex composition

Age-sex composition includes variables: percentage of population under 5 years of age (CHD), percentage of women in the age group 15-44 (WOM), and percentage of population 65 years of age and older (OLD).

Education

Education (EDU) is defined as the percentage of population not attending school full time with some university education.

Native Population

Native Population (NAT) is the percentage of the population that is 'native' (Indians, Inuit, and Metis).

Owner-occupied dwellings

Owner-occupied dwellings (OOD) is defined as the percentage of owner-occupied dwellings in a census division.

Geographic proximity

'Geographic proximity to the nearest metropolitan area' (GEP) is based on 'great circle distance', defined as the distance along a great circle passing between points i and j on the earth's surface (Hodgson, 1984:

11-12). The basic formula used in the computation of the distance (in km), as proposed by Hodgson is:

$$d_{ij} = \text{Arc}\cos[\cos(B-A)-\sin A\ \sin B(1-\cos C)]\times 6387.191 \quad (4.2\text{-}1)$$

where:

$$A = 90^\circ - lat_i$$

$$B = 90^\circ - lat_j$$

$$C = log_i - log_j$$

where lat_i and log_i refer to the latitude and longitude of census division i and lat_j and log_j are the latitude and longitude of the metropolitan area (j) nearest to the census division.

The Fortran computer program developed by Hodgson is used to estimate values of the distance (in km).

The first two sets of variables described above are treated as endogenous variables and the remaining as exogenous. These variables are available for census divisions and are similarly defined in both the 1971 and 1981 decennial censuses. Measures of education, however, did not meet these criteria. The 1981 measure is not comparable with 1971 since it is based on population 15 years and over, whereas the 1971 measure is based on population 5 years and over. Even allowing for this, however, it does confirm that there was a substantial increase from 1971 to 1981 in the proportion of persons who are university educated. The glossary of symbols, presented in Table 4.3-1, provides a guide to the mnemonic labels used in figures and tables in subsequent chapters and, hereafter, in the text.

4.4 Analysis of Covariance Structures: An Overview

In assessing the present state of methodology in the area of physician distribution, there was observed the need for more complex statistical techniques. The argument here is that the predictive power of certain variables that are associated with physician distribution can be more forcefully established by the application of statistical techniques designed to take advantage of cross-sectional and/or time series analyses. As Frisbie (1984:125) has noted, "good methodology does not guarantee a substantive contribution, but certainly no contribution will emanate from poor methodology".

In this section, a new branch of data analysis known as "structural modelling" by which the empirical estimates of the models are obtained is described. A complete technical discussion of the method is beyond the scope of this dissertation; however, the fundamentals of LISREL-type (Linear Structural Relations) structural equation modelling with its key features are briefly

Table 4.3-1

Variables and Matrices Used in the Analysis

Variable/ Matrix Symbol	Description
SPP	Specialist ratio (per 100,000 population)
GFP	General(family) practitioner ratio (per 100,000 population)
IRP	Intern and resident ratio (per 100,000 population)
BED	Hospital bed ratio (per 10,000 population)
POP	Population size (in millions)
CHD	Percentage population under 5 years of age
WOM	Percentage women aged 15-44
OLD	Percentage population 65 years and older
NAT	Percentage population that is 'native'
EDU	Percentage population 5/15 years of age and older with/without a university degree
OOD	Percentage owner-occupied dwellings
GEP	Geographic proximity (in km)
y	Observed endogenous variables
x	Observed exogenous variables
η (eta)	Unobserved endogenous variables

contd.

ξ (ksi)	Unobserved exogenous variables
B (Beta)	Coefficient matrix of unobserved endogenous variables
Γ (Gamma)	Coefficient matrix of unobserved exogenous variables
ζ (zeta)	Errors in structural equation
ϵ (epsilon)	Errors in measurment of endogenous variables
δ (delta)	Errors in measurement of exogenous variables
Ψ (Psi)	Variance-covariance matrix of structural errors
Φ (Phi)	Variance-covariance matrix of unobserved exogenous variables
Λ_y (Lambda y)	Regression coefficients relating factors to observed endogenous variables
Λ_x (Lambda x)	Regression coefficients relating factors to observed exogenous variables
Θ_ϵ (Theta epsilon)	Error variance-covariance matrix of observed endogenous variables
Θ_δ (Theta delta)	Error variance-covariance matrix of observed exogenous variables

Note: A variable with the prefix Δ denotes a change variable. e.g., ΔSPP is defined as change in specialist ratio.

discussed. To set the stage for our discussion of the LISREL model, an elementary introduction to causal modelling is necessary.

The origin of the notion of causal modelling can be traced to Wright (1918; 1934) with the formulation of path analysis. A causal model portends a theoretical structure involving the relationships among unobservable latent variables (hypothetical constructs) which are dependent, independent, or both depending upon the specified structure of the model. Although latent variables are themselves directly unobservable, they can be ascertained by one or more variables; the observed variables may be regarded as indicators of the latent variables. The fundamental question with regard to mesurement of variables is how validly and reliably the indicators represent the unobservables. In other words, do the observed variables x's and y's provide an accurate and consistent representation of the unobserved variables X's and Y's (Carmines and McIver, 1981). Since path analytic models utilize a single indicator for each latent variable considerable measurement error can be introduced into the causal model when the indicator is not a true representative of the latent variable. Such a problem, however, can be remedied through the use of multiple indicators of each latent variable and application of more sophisticated models such as LISREL.

Psychometricians have made the greatest contribution to problems dealing with measurement errors with the application of factor-analytic techniques. Social science methodologists employed a two-step sequential procedure in examining the relationship among unobserved variables: observed variables are first factor-analyzed to obtain a single composite index, and the index is then employed in causal models. In the late 1960s, however, social science methodologists began to develop models incorporating both structural and measurement relations among variables. Result is the formulation of structural models by Jöreskog and his colleagues (Jöreskog, 1973; 1977a; 1977b; 1978; Jöreskog and Sörbom, 1981a; 1981b; 1986). Causal modelling developed by Jöreskog and Sörbom is known as the linear structural relationship model, or simply LISREL. It has received greater attention in recent years, and has been used widely in social science and related sub-disciplines. To date, however, it has received little application in medical research.

Though the LISREL model bears some similarities to path-analytic models, the former is far less restrictive. More specifically, LISREL models can easily handle errors in measurement, correlated errors and residuals, and both recursive and reciprocal effects. Another important distinction is that LISREL uses maximum likelihood estimation (ML), while, path-analytic models use the ordinary least squares (OLS) procedure. The maximum likelihood estimation is a *full information* approach, one in which all the parameters are estimated simultaneously. LISREL, basically a combination of path analysis and factor analysis, is a widely accepted and mathematically very efficient tool for exploring simultaneously both substantive and measurement relationships among variables within a single theory-testing framework. As Cliff (1983:115) notes, LISREL represents, "perhaps the most important and influential statistical revolution to have occured in the social sciences ... since the adoption of analysis of variance by experimental psychology in the 1940s." It is currently in its sixth version and is implemented in the LISREL VI computer program. The computer program is extremely flexible; it can accommodate virtually any type of causal model.

The LISREL model provides a unified approach to theory building and data anlysis. This is accomplished by allowing the researcher to simultaneously evaluate the parameters of the two models: the structural (or causal) model that describes the theoretical causal relationships among the latent variables (underlying factors of interest) through a set of general linear equations; and the measurement model that describes the measurement of the latent variables by the observed indicators.

The structural modelling procedures are ideal in such situations where the researcher is unable, on a priori grounds, to choose among several slightly different versions of the same model (Heady et al. 1985). One can make the best of the measurement model procedures if multiple indicators are employed for each latent variable. LISREL VI computer program calculates a factor loading (or reliability coefficient) for each indicator and calculates disattenuated covariances among factors to help evaluate the measurement properties of variables.

The basic LISREL model is defined by the following eight parameter matrices:

(1) B (beta)is an (mxm) matrix of coefficients of the direct effects of latent endogenous constructs on each latent endogenous construct;

(2) Γ (gamma) is an (mxn) matrix of coefficients of the direct effects of the exogeneous constructs on latent endogenous constructs;

(3) Φ (phi) is an (nxn) variance-covariance matrix (symmetric) of the latent exogenous constructs;

(4) Ψ (psi) is an (mxm) symmetric variance-covariance matrix of the disturbances; ζ (zeta) is a vector of disturbances in the equations for the endogenous

constructs;

(5) Λ_y (lambda y) is a (pxm) regression matrix of the endogenous variables or indicators (observed) y_1, y_2, ..., y_p on the endogenous constructs (latent) η_1, η_2, ..., η_m (eta's), where p is the number of indicators of the endogenous constructs and m is the number of endogenous constructs;

(6) Λ_x (lambda x) is ~~a (qxn)~~ regression matrix of the exogenous variables or indicators (observed) x_1, x_2, ..., x_q on the exogenous constructs (latent) ξ_1, ξ_2, ..., ξ_n (ksi's), where q is the number of the indicators of exogenous constructs and n is the number of exogenous constructs;

(7) Θ_ϵ (theta epsilon); and

(8) Θ_δ (theta delta) are symmetric variance-covariance matrices ((pxp) and (qxq) respectively) of ϵ (epsilon) and δ (delta) respectively; ϵ(px1) and δ(qx1) are vectors of errors in the measurement of the exogenous and endogenous variables respectively.

To fit a LISREL model requires the specification of the elements of the eight matrices described above according to whether they contain (1) parameters that are *fixed* (0 or 1); (2) parameters that are *free* which are unknown and are estimated by the LISREL computer program; and (3) parameters that are unknown and are *constrained* to equal one or more other parameters in the specified model. In general, the parameters are assigned as being either fixed, free, or constrained on the basis of explicit theoretical considerations (This statement will be more clear in Chapter 6).

The matrices listed above may now be used to write the equations defining the structural and measurement models. The structural equation model consisting of a system of linear structural equations may be written as:

$$\eta = B\eta + \Gamma\xi + \zeta \qquad (4.4\text{-}1)$$

It may also be assumed that ζ is uncorrelated with ξ and that B is nonsingular (i.e., invertible).

The equations defining the measurement model of η (endogenous constructs) and ξ (exogenous constructs) respectively are:

$$Y = \Lambda_y\eta + \epsilon \qquad (4.4\text{-}2)$$

$$X = \Lambda_x\xi + \delta \qquad (4.4\text{-}3)$$

The errors of measurement ϵ and δ are assumed to be uncorrelated and uncorrelated with the latent variables.

By combining the structural and measurement equations into a single system, the variance-covariance matrix (Σ) of all observed variables (indicators of the exogenous or endogenous constructs) may be represented as (Carmines and McIver, 1981:71):

$$\Sigma = \begin{bmatrix} \Lambda_y(B^{-1}\Gamma\Phi\Gamma' B'^{-1} + B^{-1}\Psi B'^{-1})\Lambda'_y + \Theta_\epsilon & \Lambda_y B^{-1}\Gamma\Phi\Lambda'_x \\ \Lambda_x\Phi\Gamma' B'^{-1}\Lambda'_y & \Lambda_x\Phi\Lambda'_x + \Theta_\delta \end{bmatrix}$$

$$= \begin{bmatrix} \begin{array}{c} \Sigma yy \\ \text{(covariance among y's)} \end{array} & \begin{array}{c} \Sigma yx \\ \text{(covariance between} \\ \text{y's and x's)} \end{array} \\ \begin{array}{c} \Sigma xy \\ \text{(covariance between} \\ \text{x's and y's)} \end{array} & \begin{array}{c} \Sigma xx \\ \text{(covariance among x's)} \end{array} \end{bmatrix} \tag{4.4-4}$$

In other words, the population variance-covariance matrix Σ (sigma) can be represented completely by the functions of the elements of the eight matrices outlined above. For any set of values inserted in the matrices produces one and only one variance-covariance matrix Σ among the observed indicators, but there can be several structures producing the same Σ. If two or more structures produce the same Σ, the structures are considered as equivalent. If a parameter has the same value in all equivalent structures, the parameter is said to be 'identified'. Thus, a model is said to be identified if all parameters of the model are identified (Jöreskog and Sörbom, 1977). Conversely, all identified models contain a unique set of parameters.

If Θ (theta) is a vector of order s of all the independent, free, and constrained parameters (i.e., each distinct constrained parameter is counted only once), then, the identification problem is seen as the problem of whether or not Θ is uniquely determined by Σ. As Jöreskog and Sörbom (1977) note, a necessary (but not sufficient) condition for the identification of the parameters is that

$$s \leq 1/2(p+q)(p+q+1) \tag{4.4-5}$$

if there are $1/2(p+q)(p+q+1)$ equations and s unknown elements in Θ. This simply means that when the number of unknowns is less than the number of equations, then the system can be solved.

If a parameter in Θ can be determined from Σ, the parameter is identified; otherwise the parameter is not identified. In some instances, however, a parameter can be determined from Σ in different ways, such that the parameter is said to be over-identified.

Once the model is specified correctly and determined if it is identified, one is in a position to estimate the unknown parameters of the model from the sample variance-covariance matrix S by using the methods: (1) unweighted least squares (ULS); (2) generalized least squares (GLS); and (3) maximum likelihood (ML). We will confine our discussion to the maximum likelihood procedure which provides consistent and "asymptotically efficient" (i.e., the parameters have the minimum variance of any consistent estimator in large samples) estimates. This procedure was first developed by Jöreskog (1969, 1970, 1973; Gruvaeus and Jöreskog, 1970) and used in LISREL VI to estimate covariance structures.

If one has the 'wrong' model, the covariance matrix Σ implied by the model would not correspond to the actual observed covariances among the indicators (which is denoted by S). That is to say, the adequacy of the model may be assessed statistically by comparing the implied (Σ) and observed (S) variance-covariance matrices. Put differently, if S–Σ is small, the model accurately "fits" the data. The closeness of the match between Σ and S provides not only a criterion for determining the accuracy of the fit of the model, but also a criterion for deciding upon the best estimates for the 'free' parameters in any given model.

In fitting Σ to the observed variance-covariance matrix S, maximum likelihood minimizes a mathematical function, say F, with respect to the unknown parameters. The fitting function used by Jöreskog (1977b, 1978) is:

$$F = \log|\Sigma| + \mathrm{tr}(S\Sigma^{-1}) - \log|S| - (p+q) \qquad (4.4\text{-}6)$$

which is minimized with respect to Θ (theta). It follows that logarithm of the likelihood of Σ reaches its maximum when F reaches its minimum, and values of the parameters that provide the lowest value of the function F are the maximum likelihood estimates of the unknown parameters in the model. In practice, the coefficients having the largest partial derivatives represent the places where changes in coefficient values can provide the greatest improvement in the fit function F (Hayduk, 1987).

The parameter estimates that give the lowest values of F are the maximum likelihood estimates. Carmines and McIver (1981) have discussed some of the properties of these estimates. These researchers suggest that if the distribution of the variable is multivariate normal, then the parameter estimates are 'consistent' i.e., they have the minimum variance of any consistent estimates in large samples. The authors however, note that the properties of these estimates are little known if the data are not multivariate normal (exception to this statement is the work of Bentler and Weeks (1980) who proposed a method for estimating covariance structures that does not assume multivariate normality).

Once the maximum likelihood estimates of the parameters have been obtained, the goodness of fit of the model can be tested for statistical significance in large samples by a chi-square or the likelihood-ratio test. If the model holds in large samples, the likelihood-ratio follows the chi square distribution with degrees of freedom (df) equal to the number of observed moments (variance or covariance), less the number of unknown parameters to be estimated under the specification of the model.

$$df = 1/2(p+q)(p+q+1)-s \qquad (4.4\text{-}7)$$

where p is the total number of indicators of the endogenous constructs, q is the total number of indicators of the exogenous constructs, and s is the number of unknown parameters to be estimated under the specification of the model (Sörbom and Jöreskog, 1981).

A high value of chi square relative to the degrees of freedom suggests a low probability that the hypothesized model could have produced the observed covariances S; a low value of chi square suggests that the model fits the data fairly well. If the value of chi square obtained is large relative to its degrees of freedom, the fit of the model may also be judged through inspection of (1) the magnitude of the first-order derivatives (slopes) of the fit function F for the fixed parameter(s) and (2) the matrix of S−Σ residuals, that is, the discrepancies between observed and reproduced variances and covariances (these are obtained by the computer program). Such an examination may guide one to relax the model by allowing additional fixed parameters to become free, in order to arrive at a better fitting model. If the drop in the value of chi square, after revision of the model is large relative to the difference in the degrees of freedom, it indicates a 'significant' improvement in the fit of the model. On the other hand, a drop in the value of chi square which is close to the difference in number of degrees of freedom indicates a 'minimal' improvement in the fit of the model and the improvement in fit is obtained due to a chance occurence.

The primary reason for modifying a model, however, is not to obtain a 'significant' fit of the model. As Lomax (1982:4) has suggested:

> "Modifications should not be made when they are inconsistent with the underlying theory, but rather, only when the changes are meaningful to the researcher. Thus, the major goal of LISREL-type structural equation modelling is confirmatory, in the sense of substantiating some theory, and exploratory, in the sense of making finer theoretical distinctions than were intially hypothesized."

The latest version of the LISREL computer program is LISREL VI.6. Three versions of it are currently available:

1. stand-alone version, available as a leased load module;
2. SPSSx- version, available as an add-on User-Procedure for SPSSx. This is accessable for all computer systems for which SPSSx is available, and
3. PC - LISREL, a LISREL VI stand-alone for the IBM, PC, XT, AT, and Compatibles.

LISREL VI.6 computer program yields numerous types of results. Some of those which are of particular interest to us are listed below with their main features.

(1) A range of "goodness-of-fit" measures to evaluate both particular linkages among observed indicators (notably modification indices based on first and second order partial derivatives) and to assess the combined measurement and structural model. These measures include: (a) adjusted goodness of fit index (AGFI) based on the fit between the observed variance-covariance matrix and the matrix implied by the model, with adjustment for degrees of freedom in the model; (b) the root mean square residual (RMSR), which is a measure of the average descrepancy between observed and predicted variance-covariance matrices; (c) a coefficient of determination for each endogenous

construct; and (d) a chi square test (the chi square, degrees of freedom, and associated probablity level);

(2) The standardized and unstandardized estimates of the free parameters in the eight matrices (The standardized solution is preferable to the maximum likelihood solution if standardization of the construct is advisable);

(3) Factor loadings and error terms for the exogenous indicators (the Λ_x and Θ_δ matrices) and for the endogenous indicators (the Λ_y and Θ_ϵ matrices);

(4) The two key matrices in the structural model that show linkages between endogenous constructs (the Beta matrix) and between exogenous and endogenous constructs (the Gamma matrix);

(5) The Phi (Φ) - disattenuated variance-covariances among exogenous constructs; this parallels the correlations among the predictors in multiple regression - and Psi (Ψ) - variances not accounted for in endogenous constructs;

(6) Modification indices (a chi-square measure) for each constrained parameter (when any one of these exceeds a criterion level for one of the constrained parameters, the specification is probably wrong, and the parameter needs to be freed);

(7) Residual covariances (i.e., the difference between the observed moments and the estimated moments) and a Q

plot, which point to the closeness of the match between observed variance-covariance and those implied by the model;

(8) Direct and indirect effects and total effects of variables on one another;

(9) The standard errors and T values for each free parameter; they indicate those that do not differ significantly from zero may be safely constrained to this value in the specified model; and

(10) When the model is not identified, the program identifies the parameter to detect where the problem lies.

In conclusion, the foregoing discussion provides a general approach to handling simultaneously both substantive and measurement relationships among variables within the framework of theory-testing. By allowing the parameters of the model to be fixed, free or constrained, great flexibility is obtained, in that the general model contains a wide range of specific models. Using the LISREL method, it is possible, taking a systematic approach, eventually to fit the best causal model to the data in the light of theoretical considerations. A primary exercise in a LISREL analysis, then, may be seen as the achievement of a reasonable fit for a model such that the structural and measurement relationships of the hypothesized model confirm reasonably well to the data at hand. The improvement in fit achieved for the model and the consequent improvement in the parameter estimates clearly indicates the value of the technique over other traditional multivariate techniques.

There are some limitations related to the structural equation modelling approach which deserve mention. LISREL assumes continuity of variables, linearity of relations, multivariate normality of data, and is based on large-sample theory. As with any regression approach, solution to these problems depends on preliminary investigation. That is, examination of plots of the variables and relationships help to understand linearity or normality. Another limitation is that LISREL cannot identify directly interaction effects; interaction terms can only be included as new variables in the analysis. A serious problem is likely to arise in the interpretation of statistical testing of models. In evaluating goodness-of-fit tests, the chi-square statistic and its associated probability level are sometimes interpreted without regard to sample size.

Finally as Bynner and Romney (1986:49) have pointed out, "the language of causal modelling may trap the naive researcher into thinking that causes have been established when a LISREL model fits the data rather than certain possible causal explanations ruled out." In other words, researchers have a temptation to accept a model that fits the data and thereby reject other plausible models that cannot be tested using the data at hand.

CHAPTER 5

AN EXPLORATORY ANALYSIS OF PHYSICIAN DISTRIBUTION

The methodological approach adopted in the analysis of data involves two stages. The first focuses on the identification of variables within each of the three sets of exogenous variables: demographic, socio-economic, and ecological. The objectives of this stage are to confirm the identification of the independent variables as determinants of physician distribution and also to eliminate some of the variables listed in Figure 3.5-1 which apparently contribute little beyond what is shown by other variables in the list.

In the second stage of the analysis, the variables that are identified as important determinants of physician distribution in the first stage are included in causal analyses as exogenous variables and the causal linkages among the variables are examined by applying the LISREL VI software (which is being prepared for SPSSx).

One widely accepted view is that relationships do not imply casuality. While bivariate and multivariate relationships such as regression analyses do not explain possible spuriousness of observed relationships or paths through which independent variables affect dependent variables, they do seem to be useful in accomplishing reduction of the original group of variables to a smaller, yet efficient set of variables. The two sections comprising this chapter present an exploratory analysis of physician distribution to identify variables that have significant net associations with the physician and bed ratios. Section 5.1 briefly notes the bivariate relationships among the five sets of variables outlined in Chapter 3. Section 5.2 presents the multivariate relationships among the variables.

5.1 Bivariate Relationships among Variables

The mean and standard deviation of each variable together with the matrix of zero-order correlations for the two time points 1971 (Time 1) and 1981 (Time 2) are presented in Tables 5.1-1 and 5.1-2. The first task is to confirm the identification of the independent variables as predictors of physician distribution. The intercorrelation matrix addresses this concern. However, before we analyze the correlation coefficients there are some important observations concerning the variable means and standard deviations in Tables 5.1-1 and 5.1-2 that should be brought into attention. Since intern and resident data at Time 1 are available for comparatively smaller number of

Table 5.1-1

Means and Standard Deviations of Each variable and Matrix of Zero-order Correlations at Time 1

	IRP	GFP	SPP	BED	POP	CHD	WOM	OLD	NAT	EDU	OOD	GEP
Mean	28.757	55.873	36.196	65.599	0.933	8.702	20.019	8.969	2.252	6.465	72.052	164.675
S. D.	86.333	65.444	90.275	46.078	2.327	1.533	1.880	3.011	5.396	2.680	10.430	158.000
IRP	1.000											
GFP	0.950**	1.000										
SPP	0.979**	0.937**	1.000									
BED	0.080	0.058	0.063	1.000								
POP	0.687**	0.617**	0.711**	0.008	1.000							
CHD	-0.125	-0.054	-0.095	-0.024	-0.081	1.000						
WOM	0.217	0.067	0.255**	-0.062	0.296**	0.109	1.000					
OLD	0.001	0.048	-0.023	0.070	0.032	-0.535**	-0.726**	1.000				
NAT	-0.088	-0.007	-0.084	0.174*	-0.068	0.456**	-0.200*	-0.117	1.000			
EDU	0.326*	0.228**	0.324**	0.088	0.434**	0.005	0.302**	-0.048	-0.019	1.000		
OOD	-0.290*	-0.124	-0.313**	-0.074	-0.439**	0.077	-0.746**	0.398**	0.034	-0.432**	1.000	
GEP	-0.046	-0.035	-0.097	0.070	0.023	0.481**	-0.025	-0.253**	0.305**	-0.032	0.008	1.000

* Significant at the 0.01 level
** Significant at the 0.001 level

Table 5.1-2

Means and Standard Deviations of Each Variable and Matrix of Zero-order Correlations at Time 2

	IRP	GFP	SPP	BED	POP	CHD	WOM	OLD	NAT	EDU	OOD	GEP
Mean	16.734	71.625	39.398	67.280	1.070	7.872	22.720	10.584	2.381	12.383	73.331	154.951
S. D.	35.612	27.415	38.356	60.155	2.463	1.170	2.162	3.241	5.878	4.633	10.073	143.320
IRP	1.000											
GFP	0.214*	1.000										
SPP	0.492**	0.260**	1.000									
BED	0.110	0.085	0.183*	1.000								
POP	0.211*	0.119	0.485**	0.044	1.000							
CHD	-0.120	-0.183*	-0.331**	0.049	-0.212**	1.000						
WOM	0.236**	-0.002	0.399**	0.020	0.287**	0.228**	1.00					
OLD	-0.120	0.081	-0.046	0.075	-0.107	-0.471**	-0.783**	1.000				
NAT	-0.081	0.093	-0.147	0.078	-0.065	0.350**	-0.164*	-0.057	1.000			
EDU	0.278**	0.185*	0.572**	0.009	0.436**	-0.131	0.362**	-0.163*	-0.030	1.000		
OOD	-0.216*	-0.100	-0.569**	-0.312**	-0.453**	0.072	-0.553**	0.279**	0.006	-0.328**	1.000	
GEP	-0.077	0.101	-0.224**	0.042	-0.187*	0.329**	-0.010	-0.251**	0.348**	-0.113	0.156*	1.000

* Significant at the 0.01 level

** Significant at the 0.001 level

census divisions, the discussion below excludes interns and residents whenever a comparison of the results between the two time points is made.

The tables clearly show that general(family) practitioners and specialists have increased in number remarkably over time. Also important is that variations in physician ratios among census divisions have dropped markedly. This is indicated by a decline in the standard deviation of general(family) practitioner ratios from 65.444 in 1971 to 27.415 in 1981, and by the decreases in the standard deviation units for specialist ratios (the standard deviations are 90.275 and 38.356 respectively for 1971 and 1981). It can be noted, then, that with the passage of time, census divisions have also become much more homogeneous with regard to average ratios of physician increase.

Although not substantial, a general improvement in hospital facilities is also evident from the tables. This is indicated by an increase in hospital bed ratios from 65.599 in 1971 to 67.280 in 1981. Age-sex composition and socio-economic status have not changed considerably over time.

In sum, comparisons of the means and standard deviations of physician variables indicate that significant changes have occured between 1971 and 1981. The magnitude of these changes are sufficiently large to stimulate further interest in an analysis of change in physician distribution.

Zero-order correlations of the predictor variables generally are moderate. Only two correlations between independent variables are substantial at Time 1: that between WOM and OLD and that between OOD and WOM: r=-0.726 and -0.746 respectively. When the correlations between independent variables are considered at time 2, only one correlation is substantial: that between WOM and OLD with r=-0.783).

Population size (POP) can be seen to have the highest correlation (+0.689) with interns and residents at Time 1. The second most important correlate of intern and resident physician distribution is EDU with a correlation coefficient of 0.326. The variables POP, WOM, EDU, and OOD are seen as significantly correlated with interns and residents at Time 2.

As with interns and residents, the two most important correlates of general(family) practitioners at Time 1 are POP and EDU with correlation coefficients of 0.617 and 0.228 respectively. On the other hand, at Time 2, the variables CHD, and EDU are significantly correlated to general(family) practitioners (GFP); the former is negatively (-0.183) and the latter is positively (0.185) associated with GFP.

The variables POP, WOM, EDU, and OOD are strongly related to specialist distribution at Time 1 (coefficients are 0.711, 0.255, 0.324, -0.313 respectively). All variables, with the exception of OLD and NAT are significantly related to specialist distribution at Time 2.

The following general conclusions have emerged:

1. Regardless of time, POP, EDU, and OOD reveal strong relationships with all three categories of physicians.
2. With one exception (i.e., the correlation coefficient for specialist ratio at Time 2), GEP is not significantly related to physician distribution. However, the variable shows some consistency across physician categories at Time 1; it is negatively related to all the three physician variables.
3. With few exceptions, OLD, WOM, and NAT have relatively weak and inconsistent patterns of relationship with all three physician variables at both Time 1 and Time 2. It appears that physician-population ratios simply do not vary by population 65 years and older and native population;
4. The strength of the relationships between BED, EDU,

and OOD and physician variables have not changed significantly over time. That is to say, direct and joint effects of these variables on physician distribution appears to have shifted.

The findings in Tables 5.1-1 and 5.1-2 indicate that there is some variability in the correlates of physician distribution over time; some predictors have clearly changed in importance betwen Time1 and Time 2. With the important exception of the relationships between OOD and GEP and physician variables, the findings presented do not appear to reveal any important shifts in the relationships reported in the literature (e.g., Marden, 1966).

Among the intercorrelations of the physician variables we find three exceptionally high coefficients (Table 5.1-1). These indicate an extremely strong relationship between interns and residents, general(family) practitioners and specialists. One may legitimately raise the question here as to whether it is necessary to treat the three physician groups as separate variables? This near identity is hardly surprising, given the relatively small sample size at Time 1. It turns out that there are only moderate associations between the groups in 1981. These results indicate clear distinction between physician groups. Therefore, it is worth provisionally treating the three groups of physicians as separate variables. Seen from a different perspective, however, these results tend to validate the dependence assumption that physicians prefer to practice among their colleagues, and as we will see below causes interpretation problems.

Note in particular the relative strength of the coefficients from the 1971 analysis, compared to the 1981 analysis. This suggests that in the 70's physician groups were less dispersed, however, in the 80's, we find relatively greater dispersion or professional isolation of physician groups. One can assume that geographical variation becomes less pronounced in the 80's than in the 70's, and this raises the question of how demographic and socio-economic factors have different effects during the two time periods. This is perhaps best approached by noting the increased effect on the physician variables (especially, specialists) of socio-economic variables (e.g., NAT and OOD) in the 80's. Note also the relatively low correlations in the 80's between demographic factors and physician variables.

The results in Table 5.1-1 and 5.1-2 give limited support to the notion that there has been a shift in relationships among physician groups. Additional information on the preceding issues is obtained by examining change in direct effects of physician categories on one another.

As we have seen, in general, zero-order correlations among the predictor variables are modest. In reducing the set of explanatory variables to only the highly significant predictors of physician distribution, caution is necessary to ensure that highly collinear variables are not included. As noted earlier, only one pair of variables i.e., WOM and OLD exceeds the correlation coefficient of 0.80, the level identified by Lewis-Beck (1980) as the beginning of a collinearity problem. One of the variables from this pair, namely WOM, is dropped from further analyses.

Before discussing the multivariate analyses, it is worth checking whether a curvilinear relationship appears between any of the dependent and independent variables. To investigate this we examined the relationship between independent and residuals of dependent variables and checked the scatter diagrams as suggested by Kenny (1979:251). The diagrams indicated no outliers for the variables. Thus, none of the associations reported in Table 5.1-1 or Table 5.1-2 appeared to be an artifact of curvilinearity. Therefore, in the models to follow we use the variables in their raw metric form.

Finally, we attempted to see if there were interaction effects between NAT and the seven independent variables and the dependent variable BED by multiplying NAT by each variable. Each of these new variables was added to the regression analyses one at a time to see if there were any significant increase in R^2. This was not the case so the possibility that demographic, socio-economic, ecological, and environmental factors have stronger effects in the presence of different proportions of the native populations can be forcefully refuted.

5.2 Multivariate Relationships among Variables

While the above findings are of importance, they pose questions involving multivariate relationships. Such questions are addressed in the following paragraphs of this section with the use of regression analyses. As mentioned earlier, this technique is used as an ad-hoc procedure for statistically screening the simultaneous effects of a wide variety of possible explanatory variables. Stepwise multiple regression, a statistical procedure that sequentially adds independent variables to a prediction equation on the basis of their ability to account for a significant portion of the remaining unexplained variance in a dependent variable, is a commonly used approach for exploratory analyses. It is believed to be an effective method to obtain maximum predictive power using the smallest possible number of explanatory variables from a large set of variables. It should be mentioned, however, that the screening of variables is not a theory-based approach, and that the prediction equation is not necessarily a representation of the true causes of variation in the dependent variable in all instances. Nevertheless, it can help to identify the best predictors so that they can be included in causal models.

Regressions were run seperately for the three physician categories (interns and residents (IRP), general practitioners and family physicians (GFP), and specialists (SPP)) and hospital beds (BED) for the two time periods under study. The following discussion will first consider results for Time 1 analyses followed by results for Time 2.

Table 5.2-1 presents the results of the multiple regression analysis with the three physician variables as dependent variables. The variables are listed in the order in which they entered the stepwise regression. Three items of information presented in the table are R^2, the partial regression coefficients (B) and the standardized regression coefficients (Beta). R^2 stands for the explained variance in the dependent variable. The R^2 change denotes how much additional variance is explained

Table 5.2-1

Results of Multiple Regression Analyses with Physician/Population Ratios and Hospital Bed/Population Ratios as Dependent Variables, Canadian Census Divisions, 1971

Independent	IRP		GFP		SPP		BED	
Variables'	B	Beta	B	Beta	B	Beta	B	Beta
POP	18.647	0.869**	20.890	0.740**	27.528	0.757**	-1.611	-0.084
CHD	-15.059	-0.147	-3.590	-0.083	-3.824	-0.060	-2.912	-0.098
OLD	-7.853	-0.310**	-3.520	-0.158**	-5.735	-0.188**	1.824	0.120
NAT	-0.188	-0.005	0.764	0.063	-0.015	-0.000	1.689	0.204**
EDU	1.216	0.043	0.411	0.016	1.536	0.045	1.449	0.083
OOD	1.832	0.214*	1.824	0.273**	1.117	0.121*	-0.546	-0.120
GEP	-0.164	-0.255**	-0.035	-0.081	-0.082	-0.143**	0.027	0.093
BED	0.133	0.068	0.109	0.074	0.170	0.076*	-	-
Constant	63.511		-37.331		3.908		97.602	
R^2(adjusted)	0.518		0.407		0.520		0.036	
SE	63.093		52.090		64.207		45.239	
F	8.798		18.982		25.783		2.124	

' The variables that met the selection criteria (F-to-enter=1.0 and Tolerance level=0.05) for IRP, GFP, SPP, and BED are: POP, CHD, OLD, OOD, and GEP; POP, OLD, OOD, GEP, and BED; POP, OLD, OOD, GEP, and BED; and CHD, NAT, EDU and GEP respectively.

* Coefficient at least 1.5 times the standard error
** Coefficient at least twice its standard error

by the addition of the independent variable (not shown in table). The sign of the partial regression coefficient indicates the direction of association holding constant the other independent variables. The Beta coefficients show, when all variables are expressed in terms of standard scores, the slope of each independent variable with respect to the dependent variable after controlling for other variables. The specific procedure in this analysis selects variables in the order of their additive contributions (Nie et al. 1975:345-47). First, the variable with the largest contribution to explained variance (R^2) is selected; then the variable that makes the next largest addition is selected; and so on. Selection criteria are specified to include only those variables that make significant contributions and only those that are not highly collinear with other variables in the selected group of variables.[4] Thus, five variables chosen by the stepwise procedure contribute significant increments to the R^2 and are not highly collinear with one another. Rather than cataloguing the significance of these five variables (a normal practice in stepwise procedure), attention will also be focused on other variables.

Inspection of the Beta coefficients or of the partial regression coefficients reveals the following variables to be positively related to interns and residents (Table

5.2-1): POP, OOD, BED, and EDU. The variables POP, GEP, OLD, and OOD are statistically significant. The importance of these four variables is supported by the magnitude of the Beta values obtained. While there are only four significant relationships, most variables behave in the fashion expected. The relationships between age composition variables and interns and residents are negative and are not in the expected direction.

The rank order of importance of the variables as judged by the magnitude of their R^2 values is (1) POP (2) GEP (3) OLD (4) OOD and (5) CHD. Although eight variables were included in the analysis, the R^2 and R^2 change values suggest the five variables described above to be the most important. The contribution to R^2 of the first of these variables is 0.471 (not shown in table). In other words, population size (POP) alone contributes 0.471 to the proportion of variance explained by the eight variables excluding population size, while the addition of geographic proximity (GEP) adds 0.052 to the proportion of variance explained by the eight variables excluding geographic proximity. It should also be mentioned that the combined contribution of R^2 (unadjusted) of the five variables is 0.579, so that the other three variables (including BED) in combination explain only 0.006 of the variance.

Table 5.2-1 also presents the results of multiple regression with general(family) practitioners as the dependent variable. As can be seen from the table, there is some consistency with intern and resident model, in that the pattern of relationships between the variables are in most cases identical. Native population (NAT), however, positively influences the distribution of general(family) practitioners while it had a negative influence on interns and residents. The positive effect, however, contradicts the pattern observed in the bivariate analysis.

The variables POP, OLD, and OOD are seen as statistically significant. Population size (POP) is the most important predictor as it entered the stepwise regression first. The variable explains 38.3 percent of the total variance in the dependent variable. The next most important variable in explaining distribution of general(family) practitioners, judged by the value of R^2 and the order of its entry into the stepwise regression, is OOD. This variable is shown to account for 2.6% additional explanatory power as indicated by the change in R^2 (not shown in Table). The other six variables (with the exception of POP and OOD) in combination explain only 2.0% of the variance.

The only major respect in which the results for specialists differ from expectations is in the age composition variables (Table 5.2-1). They have negative impacts on specialist distribution. The finding, however, is consistent with earlier results, indicating that physicians are not concentrated in areas where the two age groups are in large proportions.

The data in Table 5.2-1 show that the variables POP, OLD, OOD, GEP and BED have statistically significant effects upon specialists, independent of all other variables. Population size (POP) explains 50.4 percent of the total variation in specialist distribution. The next two most important variables in explaining specialist distribution are GEP and OLD. These variables are shown to account for 1.4% and 1.1% additional explanatory power. The importance of these variables is also evidenced by the relatively high Beta values. The five significant variables (POP, OLD, OOD, GEP, and BED) contribute increments to the R^2. The remaining variables (NAT, EDU, and CHD) only explained an additional 0.3% more of the total variance of 54.1% (unadjusted).

An examination of the results reported in Table 5.2-1 demonstrates that native population (NAT) may be strongly associated with distribution of hospital beds. The significant positive effects for this variable means that areas with large proportion of natives are characterized by large hospital bed ratios. The variable explains 3.0% of the total variation in hospital beds.

The rather low R^2 suggests that the analysis excludes the key determinants of hospital beds. The full equation could only account for 6.8% of the (unadjusted) variance in hospital beds. Neverthless, it appears that independent vaiables like NAT do have important consequences for physician distribution via hospital beds.

The Time 2 cross-sectional regression results for the three categories of physicians and hospital beds are presented in Table 5.2-2. A general comparison between Tables 5.2-1 and 5.2-2 reveals that none of the variables that were significant predictors of interns and residents at Time 1 are significant at Time 2. In addition, there are some differences in the pattern of relationships between the predictor variables and the dependent variable. For example, the coefficients for the variable OOD show signs opposite to that observed at Time 1. In 1981, areas with large proportions of owner-occupied dwellings were characterized by few intern and resident physicians whereas in 1971 large proportions of owner-occupied dwellings were characterized by a large number of intern and resident physicians.

Table 5.2-2

Results of Multiple Regression Analyses with Physician/Population Ratios and Hospital Bed/Population Ratio as Dependent Variables, Canadian Census Divisions, 1981

Independent Variables[1]	IRP B	IRP Beta	GFP B	GFP Beta	SPP B	SPP Beta	BED B	BED Beta
POP	0.546	0.042	0.093	0.009	1.607	0.111*	-1.624	-0.068
CHD	-4.085	-0.119	-5.276	-0.227**	-5.021	-0.149**	8.133	0.160**
OLD	-1.920	-0.158*	0.841	0.100	0.152	0.012	5.555	0.304**
NAT	-0.634	-0.048	0.534	0.116*	-0.484	-0.075	-0.069	-0.007
EDU	1.427	0.197**	1.166	0.195**	3.318	0.408**	-0.307	-0.024
OOD	-0.168	-0.046	-0.218	-0.080	-1.337	-0.347**	-2.776	-0.466**
GEP	-0.008	-0.034	0.040	0.208**	-0.004	-0.016	0.053	0.128*
BED	0.062	0.106	0.020	0.044	0.056	0.089*	-	-
Constant	59.515		96.626		126.960		145.279	
R^2(adjusted)	0.082		0.104		0.542		0.150	
SE	34.785		26.135		26.152		55.462	
F	2.845		4.137		28.821		6.443	

[1] The variables that met the selection criteria (F-to-enter=1.0 and Tolerance level=0.05) for IRP, GFP, SPP, and BED are: NAT, EDU, and OOD; CHD, NAT, EDU, GEP and BED; POP, CHD, NAT, EDU, OOD, and BED; and POP, CHD, OLD, OOD and GEP respectively.

* coefficient at least 1.5 times its standard error
** Coefficient at least twice its standard error

Examinations of the partial regression coefficients reveal that EDU has a significant effect upon intern and resident ratios, independent of all other variables. The second most important variable is OLD. EDU, the most powerful of all predictors, is capable of predicting 7.7% of the variance in interns and residents. It should be noted that the total variance (unadjusted) of intern and resident distribution accounted for by a combination of eight predictors is only 12.6%. This is small compared to the variance obtained for interns and residents at Time 1 (i.e., 58.5%). Interpretation of this results is complicated, however, by the fact that intern and resident data are weak, this finding raises the question of comparability of the two models at Time 1 and Time 2. Of course, the two models differ in years considered, number and size of areal units, and to some extent in variable definition (e.g., education). The relatively small proportion of variance explainable in the present model provokes speculation concerning additional variables for which data were not available, which, had they been utilized, might account for more of the variance in the distribution of intern and resident physicians.

Turning to the regresssion results for general practitioners and family physicians, few observations may be made with respect to the results shown in Tables 5.2-1 and 5.2-2. First, the variables GEP and OLD are seen as positively influencing general practitioners and family physicians at Time 2, while these variables had a negative influence on the dependent variable at Time 1. The results for the variable OLD, however, confirm the *a priori* predictions. Secondly, NAT has significant positive association with general(family) practitioners. Finally, only socioeconomic variables (EDU/OOD) significantly predict distribution of general(family) practitioners in both the time periods. These results suggest that demographic variables and especially population size (POP) become less consequential and socio-economic variables (with the exception of OOD) become more crucial at Time 2.

All variables together explain 13.7% of the variance in the distribution of general practitioners and family physicians at Time 2. Education (EDU) explains 4.0% of the total variance. The addition of CHD increases the variance to 6.8%. The third most important variable in explaining the distribution of general practitioners and family physicians is GEP . This variable is shown to account for 4.0% additional explanatory power as evident from the change in R^2 values (not shown in the Table). The importance of the above described variables are further evidenced with the higher values of standardized regression coefficients (Betas).

Table 5.2-2 also presents the results of regression of specialists' distribution on the same set of factors at Time 2. Comparison of Tables 5.2-1 and 5.2-2 reveals that two variables, OLD and OOD show different pattern of relationships with specialists over the time period. The latter, however, appears to increase in predictive power over time. Of the two variables, the former affects specialists in the expected direction, and offers support for the hypothesis that areas in which the older age-group is over represented have larger numbers of physicians and especially specialists. But, the negative coefficient of OOD contradicts the author's expectation that areas with large proportion of owner-occupied dwellings are likely to have more specialists.

The model explains 56.2% of the variance in specialist distribution. Turning to the marginal importance of predictors of specialist distribution, it can be seen that most of the variance explained is due to EDU and OOD. Education (EDU), the most important of all the predictors, explains 33.3% of the variance, whereas adding OOD resulted in an additional 16.7% increase in variance. Also important is that the variable, OLD has declined in importance over time.

Finally, the regression results with hospital beds as the dependent variable are examined (Table 5.2-2). The variables CHD, OLD, OOD, and GEP have significant Beta coefficients. These four variables explain 17.3 percent of the variance in hospital beds.

The results reported in Tables 5.2-1, and 5.2-2 do not appear to conform to a single pattern of variation in hospital bed ratios. For example, if the variable NAT was the primary factor influencing hospital beds at Time 1 it does not relate to hospital beds at Time 2. Also, the influence of CHD, NAT and EDU seem to work in the opposite direction from that observed earlier.

All the variables together explain 17.7 percent of the variance in hospital beds. This is an improvement over the equation corresponding to Time 1 (R^2=0.068), even though the traditional predictors lost their significance.

The multiplicity of factors associated with physician distribution is evident from the significant values obtained from the correlational analyses. POP, EDU, and OOD are notable factors at both the time periods. Areas with a large population size and a large proportion of highly educated persons have large physician-population ratios. This observation confirms earlier studies on physician distribution. On the other hand, contrary to our expectation, areas with a high proportion of owner-occupied dwellings tend to have lower physician-population ratios.

The four important differentiators of physician distribution at Time 1 that were revealed by the regression analyses include POP, OLD, OOD, and GEP (excluding BED, of course). Other variables such as CHD, NAT, and EDU appear to be of minor significance compared to the four factors described above. On the contrary, socio-economic factors (NAT, EDU, and OOD) take importance at Time 2. These factors explained virtually all of the variance which was explainable. Two other major factors of differentiation were also revealed by the regression analyses: POP and CHD.

By aggregating the physician groups, previous models of physician distribution have failed to discern that they respond differently to the factors influencing physician distribution. In other words, aggregation can lead to distorted estimates of regression coefficients. While the results suggest the need for further refinement of the theoretical models to account for changing demographic and socio-economic conditions, the complex relationships observed indicate that potential correlates vary across physician categories and across time points.

The regression results for hospital beds present a more complex picture than those for physicians. The results of Time 1 model indicate that the distribution of hospital beds is more responsive to social or cultural factors such as native population and educational level of the population. But demographic factors are seen as significantly associated with hospital beds at Time 2.

Before leaving this discussion of the regression analyses, it is worth noting some contrasts between the Time 1 and Time 2 analyses in detail. The R^2 values for 1971 models in Table 5.2-1 cannot be compared perfectly with the result for 1981 in Table 5.2-2 mainly because slightly different variables are involved for each time. Except for specialists and hospital beds, the values of R^2 for 1981 models are relatively small. These results are presumably indicative of a decrease in the degree to which associations between the predictors and physician groups have waned in the case of intern (resident) physicians and general(family) practitioners. To put it differently, the change may be due to a shift in the variance of the dependent variables. This evidently is not the case with specialists; the values for R^2 at Time 1 and Time 2 are nearly equal.

A change in R^2 may occur for a number of reasons which are worth spelling out in detail. First, a change in variability of the predictors can alter their ability to explain variance. Second, a change in the intercorrelation among predictors may also change the proportionate level of explanation. Finally, an overall change in R^2 can come about because the importance of individual predictors (the zero-order correlations with the dependent variables) shifts over time. A notable finding in our analyses is that the effects of certain predictors have changed substantially over time. We see that R^2 is different because particular variables have changed in importance.

A decrease in the effect of demographic factors could result from changes in the provision or use of medical services and other changes that have altered the differential use of such services. But, no completely satisfactory explanation exists to account for why the role of traditional factors has been decreasing. It may be added that there has, in fact, been considerable progress towards 'equality' in service provision. Variation in physician ratios across regions still exists but it is not nearly as steep as it was ten or twenty years ago.

In connection with the argument about the declining role of demographic factors, we can show that there has been an increase in the explanatory power of socio-economic factors. Declines in the Beta coefficients associated with demographic factors imply that in conjunction with the other variables, demographic factors contribute less to explaining physician distribution in recent years. When we consider these apparent differences in the coefficients of demographic factors, we are probably correct in concluding that demographic factors are coming to play a less important role in distribution patterns especially in small area analysis. Marden (1966), for example, observed that the strength of the population effect declines systematically with decreasing city size. Regression models only weakly reflect such changing facets of demographic factors. Additional information on these issues is obtained by examining analysis of change models.

The following chapters include discussion of structural equation models incorporating several causal-order assumptions. The causal models estimated in the later portion of this dissertation carry the results significantly beyond our earlier reporting of bivariate and multivariate relationships among the variables. On a general note, this exercise has at least three major advantages (Abbey and Andrews, 1985:12-13):

(1) The models provide estimates of both the inter-relationships and causal effects among the variables;

(2) The models permit disaggregation of the effects into direct, indirect, and non-causal components; and

(3) The models are useful heuristically, i.e., they

indicate what the causal structure should be in order to produce the relationships that are observed.

However, the reader may note that there is considerable dispute about the meaning of the word "cause". For the present purposes, using a strategy similar to that of Headey et al. (1984), we regard X as a cause of Y if (i) changes in X precede changes in Y, (ii) X is correlated with Y, and (iii) the correlation is not spurious in the sense that it does not depend on some third antecedent variable. But, it is important to stress the fact that we cannot be certain of the time sequences -- that changes in X precede changes in Y. This fact makes causal conclusions drawn from cross-sectional data problematic. It follows that it is necessary to make certain assumptions about time sequences in developing causal models. We made the following causal-order assumptions: demographic, socio-economic, and ecological variables affect environmental/ technological variables, which in turn affect physician variables.

The cross-sectional structural equation models presented in the next chapter are intended to demonstrate the validity of our stated causal-order assumptions. However, the data could fail to substantiate our theory if, given our assumptions, we fail to support the hypotheses. It is possible with cross-sectional data that causality runs in the opposite direction. With longitudinal data, however, the situation is clearer, causal effects show up either simultaneously or with time lag, but do not operate backwards in time (Abbey and Andrews, 1985:13). In the modelling analyses reported in this dissertation, results from both cross-sectional and change models are discussed.

We first restricted the models by eliminating from each model any variable which did not meet the selection criteria (ie, F = 1.0 and Tolerance = 0.05) specified in the regressions. In other words, only those variables that made significant contributions and were not highly collinear with others in the selected subset of variables were considered (see footnotes for Tables 5.2-1 and 5.2-2). However, such restrictions had to be relaxed in some cases in order to overcome the problem of identification.

Several different models were examined both for their theoretical meaning and their relative fit. Consequently, some of the links which were found insignificant in the regression analyses were included to arrive at best-fitting models. Only the best-fitting models will be described. The stability of parameter estimates were, however, checked by reestimating the models by excluding non-significant effects. The models which included only the significant paths were not substantially different from those reported; the significance pattern was the same as were the relative magnitudes of individual effects.

CHAPTER 6

PHYSICIAN DISTRIBUTION: AN INVESTIGATION OF CAUSAL STRUCTURES

This chapter presents results of causal analyses of physician distribution using the four broad factors - demographic, socio-economic, ecological and environmental/ technological - that make up the theoretical framework and discuss how these factors contribute to the structural complexity of three groups of physicians - interns and residents, general practitioners and family physicians, and specialists - seperately and also in combination. The data for the two census years are analyzed separately and the parameter estimates of the models are discussed. As a first step towards building the models, the structural and measurement components of the models, outlining theoretical specifications are discussed. The sections 6.2 and 6.3 focus on parameter estimates of the models respectively for the two time points, Time 1 and Time 2.

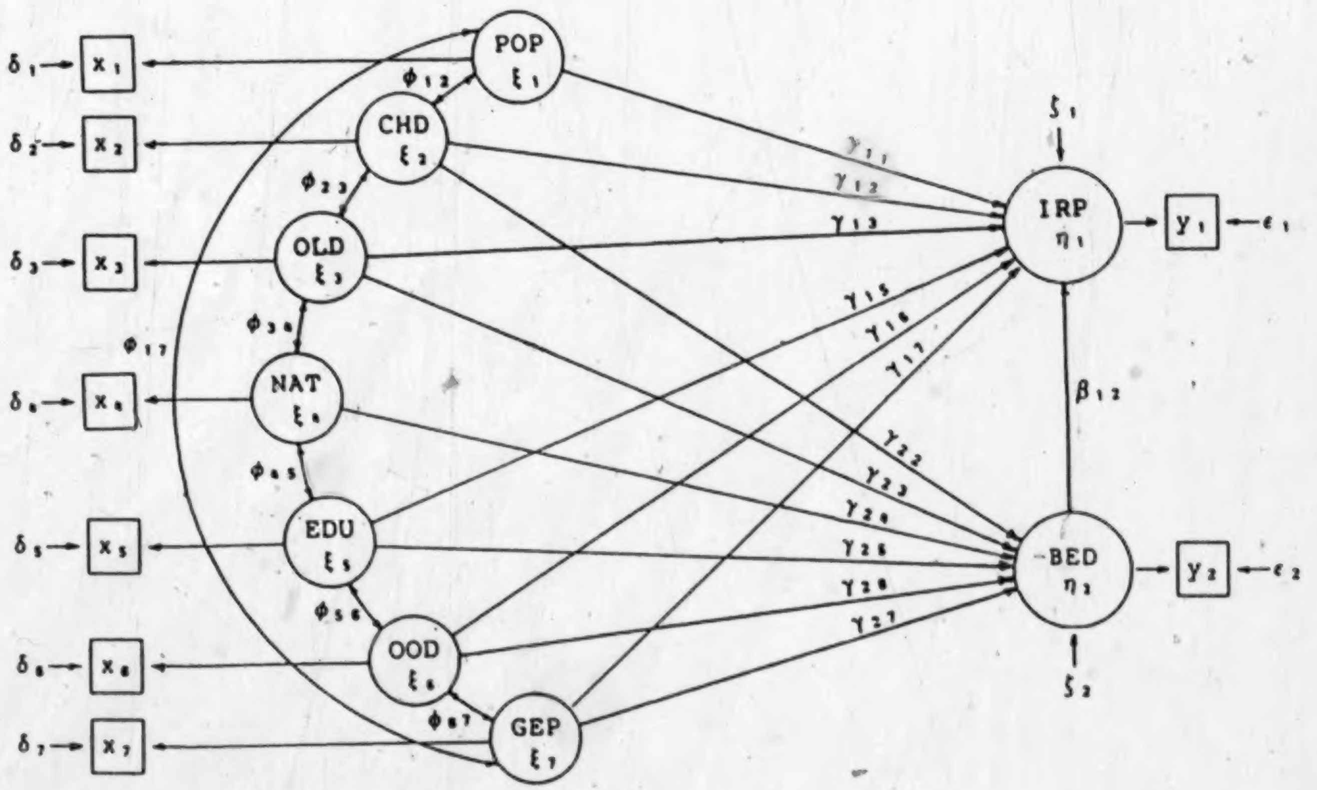
6.1 Specification of Models

Although this section does not consider the estimation of parameters of the models, a first step towards building recursive and nonrecursive models of physician distribution is undertaken with a detailed description of the specification of models at Time 1. The discussion here will ground the discussions in subsequent sections.

6.1.1 Structural and Measurement Components of Models at Time 1

The models presented in Figures 6.1-1, 6.1-2, and 6.1-3 address the issue of the relationship between demographic, socio-economic, ecological and environmental factors and the three categories of physicians: interns and residents, general practitioners and family physicians, and specialists respectively. Figure 6.1-4 presents a combined model with the hypothesized relationship between the variables and the latter two categories of physicians. The first three models contain nine variables including seven exogenous and two endogenous. They are: POP, CHD, OLD, NAT, EDU, OOD, GEP, BED, and IRP/GFP/SPP.

With respect to the relationships between the exogenous variables, (POP, CHD, OLD, NAT, EDU, OOD, and GEP) and the endogenous variable BED, Figure 6.1-1 indicates that all the variables with the exception of POP have a direct effect on hospital beds (BED). All the variables, with the exception of NAT are hypothesized to have direct influences on interns and residents (IRP). In


POP ξ_1
CHD ξ_2
OLD ξ_3
NAT ξ_4
EDU ξ_5
OOD ξ_6
GEP ξ_7
IRP η_1
BED η_2
x_1
x_2
x_3
x_4
x_5
x_6
x_7
δ_1
δ_2
δ_3
δ_4
δ_5
δ_6
δ_7
y_1
y_2
ϵ_1
ϵ_2
ζ_1
ζ_2
β_{12}
ϕ_{12}
ϕ_{23}
ϕ_{34}
ϕ_{45}
ϕ_{56}
ϕ_{67}
ϕ_{17}
γ_{11}
γ_{12}
γ_{13}
γ_{15}
γ_{16}
γ_{17}
γ_{22}
γ_{23}
γ_{24}
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γ_{26}
γ_{27}

Figure 6.1-1 The Causal Diagram Describing Effects of Demographic, Socio-economic, Ecological, and Environmental Factors on Interns and Residents Distribution at Time 1

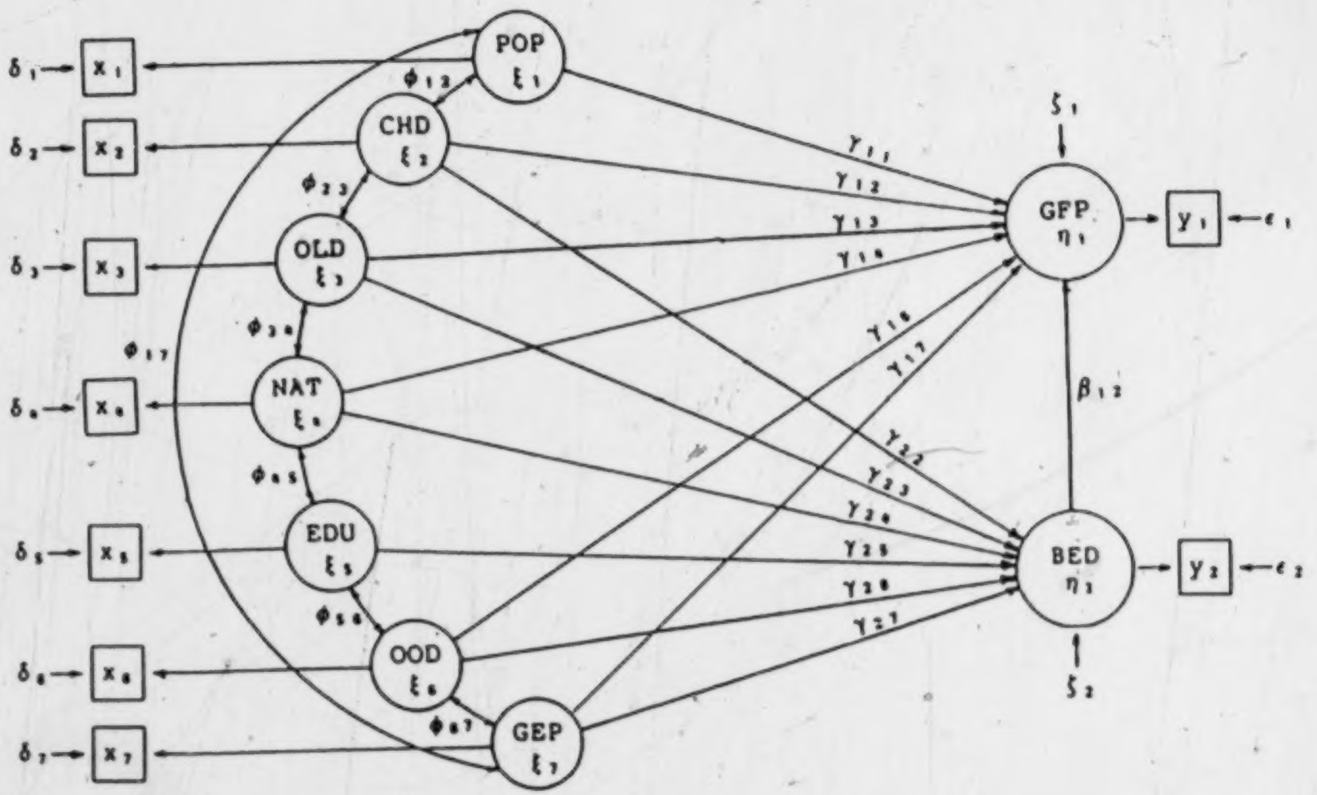

POP ξ_1
CHD ξ_2
OLD ξ_3
NAT ξ_4
EDU ξ_5
OOD ξ_6
GEP ξ_7
GFP η_1
BED η_2
x_1
x_2
x_3
x_4
x_5
x_6
x_7
δ_1
δ_2
δ_3
δ_4
δ_5
δ_6
δ_7
y_1
y_2
ϵ_1
ϵ_2
ζ_1
ζ_2
ϕ_{12}
ϕ_{23}
ϕ_{34}
ϕ_{45}
ϕ_{56}
ϕ_{67}
ϕ_{17}
γ_{11}
γ_{12}
γ_{13}
γ_{14}
γ_{16}
γ_{17}
γ_{22}
γ_{23}
γ_{24}
γ_{25}
γ_{26}
γ_{27}
β_{12}

Figure 6.1-2 The Causal Diagram Describing Effects of Demographic, Socio-economic, Ecological, and Environmental Factors on General (Family) Practitioners Distribution at Time 1

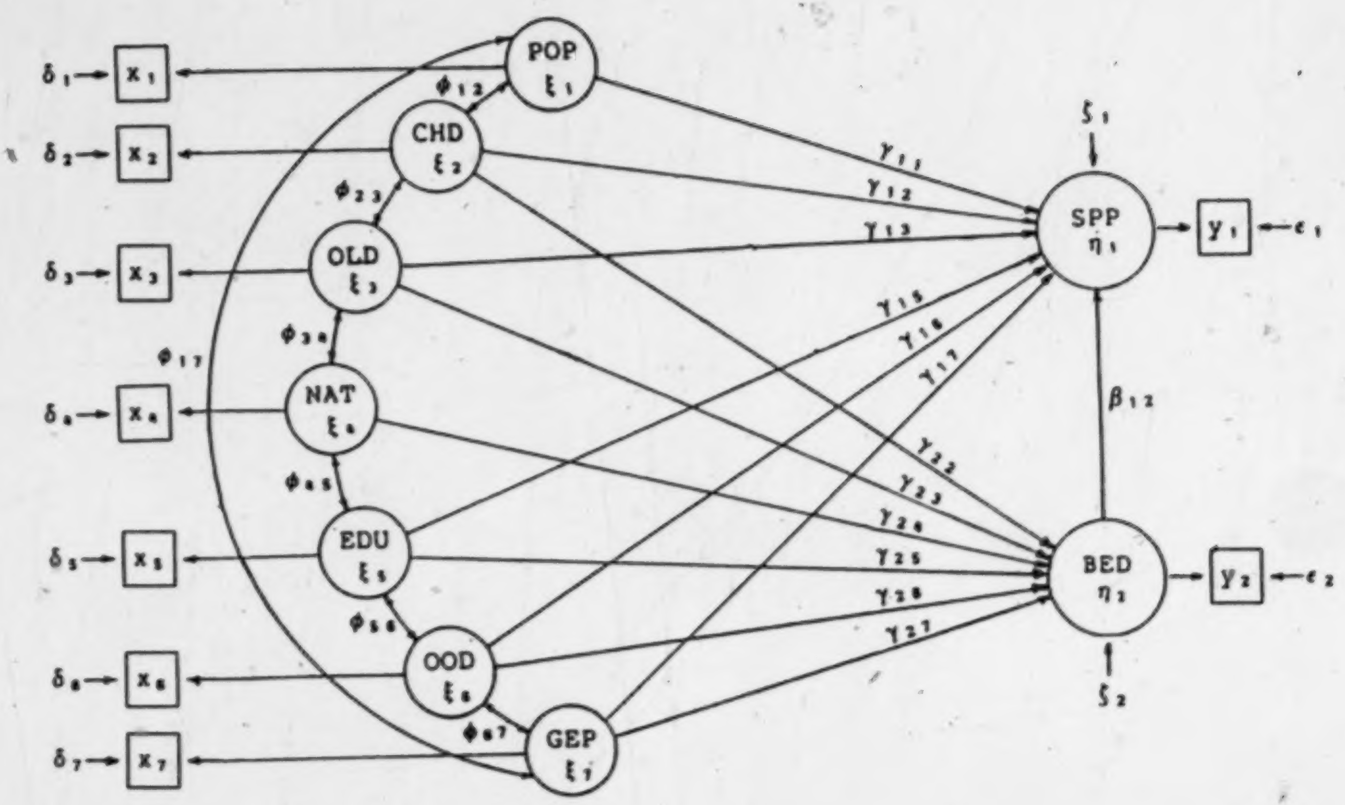

δ_1 x_1
δ_2 x_2
δ_3 x_3
δ_4 x_4
δ_5 x_5
δ_6 x_6
δ_7 x_7
POP ξ_1
CHD ξ_2
OLD ξ_3
NAT ξ_4
EDU ξ_5
OOD ξ_6
GEP ξ_7
ϕ_{12}
ϕ_{23}
ϕ_{34}
ϕ_{45}
ϕ_{56}
ϕ_{67}
ϕ_{17}
γ_{11}
γ_{12}
γ_{13}
γ_{15}
γ_{16}
γ_{17}
γ_{22}
γ_{23}
γ_{24}
γ_{25}
γ_{26}
γ_{27}
ζ_1
SPP η_1
y_1 ϵ_1
β_{12}
BED η_2
y_2 ϵ_2
ζ_2

Figure 6.1-3. The Causal Diagram Describing Effects of Demographic, Socio-economic, Ecological, and Environmental Factors on Specialists Distribution at Time 1

addition, the endogenous variable BED is allowed to affect interns and residents directly.

The decision to omit the paths are based on the results of regression analyses. The regression results presented in Chapter 5 showed that NAT has little or no relevance at all in explaining the distribution of interns and residents. The results also showed that the effect of POP on BED is nonsignificant or very weak. The argument here is that we omitted effects which are rather small or completely zero. No effect was eliminated on *a priori* grounds. This is in accordance with the view that the theory should never be adjusted by *omitting* effects which are specified as important in the model, since this will produce biased values for the other parameters if these effects are really important (Saris and Stronkhorst, 1984:140).

Note that the three models are formally the same, in most cases, with identical paths between the variables; thus their structure can be represented in the same way in the LISREL framework. In other words, the matrix representations of the structural (and measurement) parts of the models remain the same. The model in Figure 6.1-2, however, differs from the other two. For both interns and residents, and specialists, effect from NAT is hypothesized to be absent. For general practitioners and family physicians, on the other hand, it is the effect of EDU that is hypothesized as absent.

The structural relations among the variables in the models can be expressed in the form of the basic equation 4.4-1 after designating the constructs with the Greek characters used in the LISREL.

POP ≡ ξ_1 (ksi sub 1)
CHD ≡ ξ_2 (ksi sub 2)
OLD ≡ ξ_3 (ksi sub 3)
NAT ≡ ξ_4 (ksi sub 4)
EDU ≡ ξ_5 (ksi sub 5)
OOD ≡ ξ_6 (ksi sub 6)
GEP ≡ ξ_7 (ksi sub 7)

IRP/GFP/SPP ≡ η_1 (eta sub 1)
BED ≡ η_2 (eta sub 2)

$$\begin{bmatrix}\eta_1\\ \eta_2\end{bmatrix} = \begin{bmatrix}0 & \beta_{12}\\ 0 & 0\end{bmatrix}\begin{bmatrix}\eta_1\\ \eta_2\end{bmatrix} + \begin{bmatrix}\gamma_{11} & \gamma_{12} & \gamma_{13} & 0 & \gamma_{15} & \gamma_{16} & \gamma_{17}\\ 0 & \gamma_{22} & \gamma_{23} & \gamma_{24} & \gamma_{25} & \gamma_{26} & \gamma_{27}\end{bmatrix}\begin{bmatrix}\xi_1\\ \xi_2\\ \xi_3\\ \xi_4\\ \xi_5\\ \xi_6\\ \xi_7\end{bmatrix} + \begin{bmatrix}\zeta_1\\ \zeta_2\end{bmatrix} \qquad (6.1\text{-}1)$$

$$\eta = B\eta + \Gamma\xi + \zeta$$

For the model in Figure 6.1-2, γ_{15} is replaced by zero instead of γ_{14}. The numerical values of the coefficients in B and Γ are unknown and the major task will be to obtain estimates of these structural coefficients. The free parameters to be estimated therefore include β_{12}, γ_{11}, γ_{12}, γ_{13}, $\gamma_{14}(\gamma_{15})$, γ_{16}, γ_{17}, γ_{22}, γ_{23}, γ_{24}, γ_{25}, γ_{26}, and γ_{27}. The zero entries in the B and Γ matrices represent fixed parameters. For example, the zero in the second row and first column of B indicates that the causal paths from η_1 to η_2 is hypothesized to be absent (i.e., $\beta_{21}=0$).

Next, we specify measurement models that reflect how the unobserved variables are measured in terms of the observed variables. The models estimated in this study include a single indicator for each variable. Therefore, error variances cannot be estimated meaningfully (we will come to this point later in this section). Nevertheless, it is worth discussing the measurement structure of models. Thus, the matrix equations corresponding to equations 4.3-2 and 4.3-3 are:

$$\begin{bmatrix} y_1 \\ y_2 \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} \begin{bmatrix} \eta_1 \\ \eta_2 \end{bmatrix} + \begin{bmatrix} \epsilon_1 \\ \epsilon_2 \end{bmatrix} \qquad (6.1\text{-}2)$$

$$Y = \Lambda_y \eta + \Theta_\epsilon$$

$$\begin{bmatrix} x_1 \\ x_2 \\ x_3 \\ x_4 \\ x_5 \\ x_6 \\ x_7 \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} \xi_1 \\ \xi_2 \\ \xi_3 \\ \xi_4 \\ \xi_5 \\ \xi_6 \\ \xi_7 \end{bmatrix} + \begin{bmatrix} \delta_1 \\ \delta_2 \\ \delta_3 \\ \delta_4 \\ \delta_5 \\ \delta_6 \\ \delta_7 \end{bmatrix} \qquad (6.1\text{-}3)$$

$$X = \Lambda_x \xi + \Theta_\delta$$

Recalling from the discussion in Chapter 4, these two equations show that unobserved theoretical constructs η's and ξ's are related directly or indirectly to observed indicators Y's and X's respectively.

The 0's and 1's in the Λ matrices are fixed at these predecided values. The 0's force the indicator variables to respond to only the single proper underlying concept. But the 1's not only link indicators to their concepts, they also set the scale on which the values of the underlying concepts are measured. Thus, it is assumed that a unit change on the concept is scaled to be the same as a unit change on the indicator. In essence, the insertion of 1's guarantees that each unit of change in the underlying concept corresponds to a unit of change in the corresponding indicator, and hence guarantees that the scales on which they are measured have equal sized units. It is to be mentioned, however, that one is free to provide the concepts with whatever scale one wishes, but it is preferable to provide the concepts the same scales as the corresponding observed indicators in order to facilitate interpretation.

Having discussed the four matrices of structural coefficients for the model (B, Γ, Λ_x, and Λ_y), we may now turn to the remaining four covariance matrices Φ, Ψ, Θ_ϵ, and Θ_δ - that complete specification of the model.

The Φ contains the matrix of correlations between the seven exogenous variables (ξ's) and hence is a (7x7) matrix of the form:

$$\Phi = \begin{bmatrix} \phi_{11} & 0 & 0 & 0 & 0 & 0 & 0 \\ \phi_{21} & \phi_{22} & 0 & 0 & 0 & 0 & 0 \\ \phi_{31} & \phi_{32} & \phi_{33} & 0 & 0 & 0 & 0 \\ \phi_{41} & \phi_{42} & \phi_{43} & \phi_{44} & 0 & 0 & 0 \\ \phi_{51} & \phi_{52} & \phi_{53} & \phi_{54} & \phi_{55} & 0 & 0 \\ \phi_{61} & \phi_{62} & \phi_{63} & \phi_{64} & \phi_{65} & \phi_{66} & 0 \\ \phi_{71} & \phi_{72} & \phi_{73} & \phi_{74} & \phi_{75} & \phi_{76} & \phi_{77} \end{bmatrix} \qquad (6.14)$$

By this, the exogenous variables are assumed to be related to each other. The remaining three matrices are variance-covariance matrices among the three types of error terms - ζ, ϵ, and δ that appear in the model: errors in prediction of the endogenous concepts η's by the conceptual level variables (contained in Ψ); errors in measurement of the endogenous concepts (contained in Θ_ϵ); and errors in measurement of the exogenous concepts (contained in Θ_δ).

The models specify that while some errors are expected in the prediction of the endogenous constructs, no variance is expected among these errors. Thus Ψ is a diagonal matrix of the form:

$$\psi = \begin{bmatrix} \psi_{11} & 0 \\ 0 & \psi_{22} \end{bmatrix} \tag{6.1-5}$$

All other variables not included in the model are assumed to have minor effects, to cancel each other out, and are unrelated to the two endogenous constructs ($E(\zeta)=E(\eta)=E(\xi)=0$; $E(\xi\zeta')=0$; $E(\zeta\xi')=0$; $E(\epsilon\epsilon')=\theta\epsilon$; $E(\zeta\zeta')=\psi$; $E(\delta\delta')=\theta\delta$). $\Theta\epsilon$ and Θ_δ are of the form:

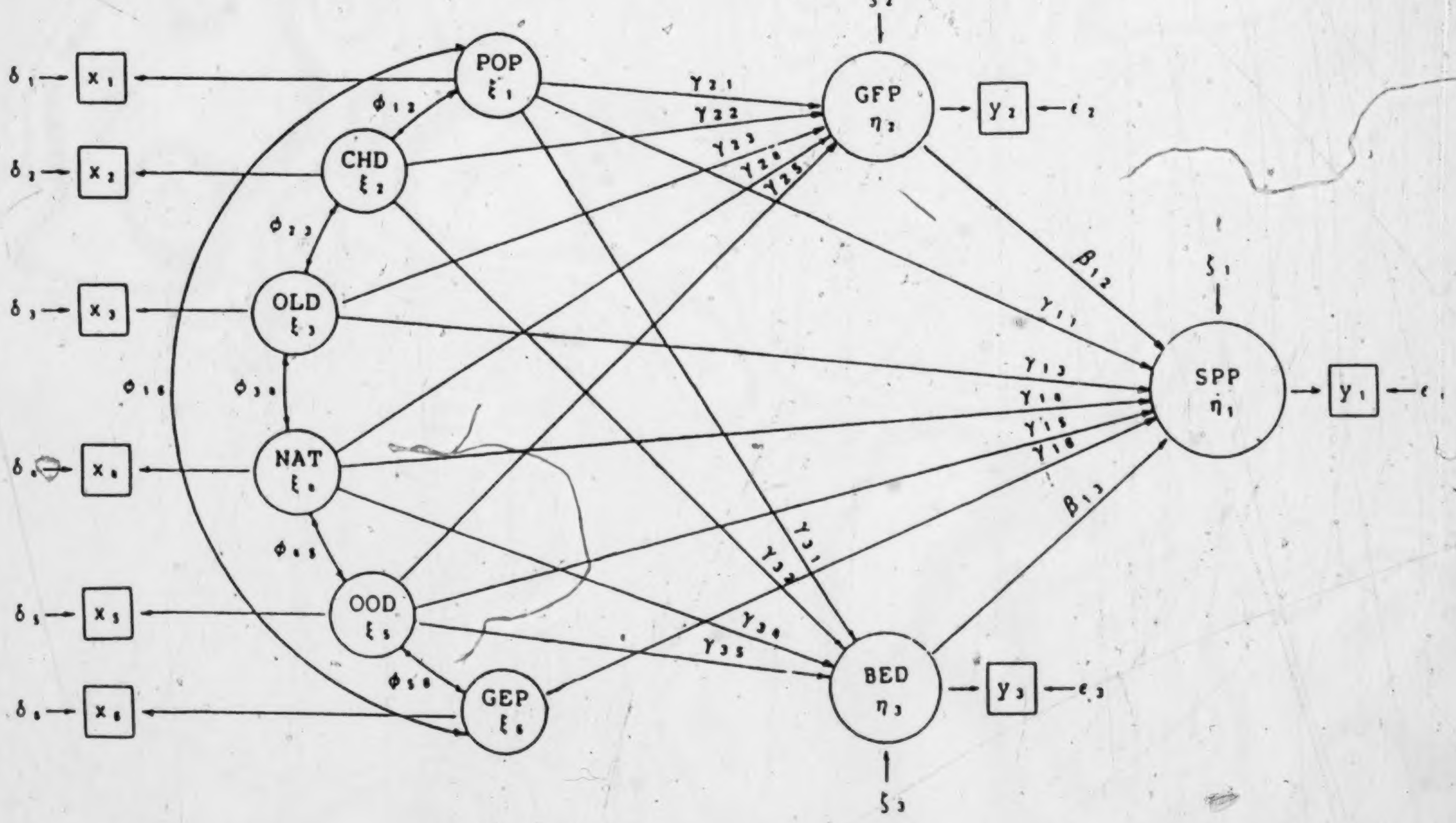
$$\Theta_\epsilon = \begin{bmatrix} \theta_{\epsilon 11} & 0 \\ 0 & \theta_{\epsilon 22} \end{bmatrix} \tag{6.1-6}$$

$$\Theta_\delta = \begin{bmatrix} \theta_{\delta_{11}} & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & \theta_{\delta_{22}} & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & \theta_{\delta_{33}} & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & \theta_{\delta_{44}} & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & \theta_{\delta_{55}} & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & \theta_{\delta_{66}} & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & \theta_{\delta_{77}} \end{bmatrix} \quad (6.1\text{-}7)$$

For latent constructs that have only a single indicator each, it is not possible to assess the extent of measurement error. In such instances, a usual procedure is to assume that the observed variables are valid and reliable measures of the latent variable and accordingly set the δ and/or ϵ elements equal to zero. For example, in the case of Figures 6.1-1, 6.1-2, and 6.1-3, we must set $\epsilon = \delta = 0$.

For the present purpose, however, the error variances (Θ_ϵ and Θ_δ values) are fixed. Thus, the values ,in the diagonal of equation 6.1-6 and 6.1-7 are not estimated, but are fixed, as will be discussed later in this section.

Next we turn to the specification of the combined model (Figure 6.1-4) which includes general(family) practitioners (GFP), and specialists (SPP) but excludes interns and residents (IRP). The combined model employs



δ_1
x_1
δ_2
x_2
δ_3
x_3
δ_4
x_4
δ_5
x_5
δ_6
x_6
POP ξ_1
CHD ξ_2
OLD ξ_3
NAT ξ_4
OOD ξ_5
GEP ξ_6
ϕ_{12}
ϕ_{23}
ϕ_{34}
ϕ_{16}
ϕ_{45}
ϕ_{56}
γ_{21}
γ_{22}
γ_{23}
γ_{24}
γ_{25}
γ_{31}
γ_{32}
γ_{34}
γ_{35}
γ_{11}
γ_{13}
γ_{14}
γ_{15}
γ_{16}
β_{12}
β_{13}
ζ_2
GFP η_2
y_2
ϵ_2
ζ_1
SPP η_1
y_1
ϵ_1
ζ_3
BED η_3
y_3
ϵ_3

Figure 6.1-4 The Causal Diagram Describing Effects of Demographic, Socio-economic, Ecological, and Environmental Factors on General (Family) Practitioners and Specialists Distribution at Time 1

all those factors which remain statistically significant in the earlier models. The model employs six exogenous variables (POP = ξ_1; CHD = ξ_2; OLD = ξ_3; NAT = ξ_4; OOD = ξ_5; and GEP = ξ_6) and three endogenous variables (SPP = η_1; GFP = η_2; and BED = η_3).

As indicated in the figure, the model illustrates that all the exogenous variables with the exception of GEP are directly linked to general practitioners and family physicians (η_2). The endogenous variable specialists (η_1) is influenced by all exogenous variables except CHD. And the variables, with the exceptions of OLD and GEP are hypothesized to have a direct effect on hospital beds (η_3). General(family) practitioners (η_2) and hospital beds (η_3), in turn, are hypothesized to affect specialists (η_1).

Applying the same rules as that of earlier specifications, the structural relations among the constructs in the model may be written as:

$$\begin{bmatrix} \eta_1 \\ \eta_2 \\ \eta_3 \end{bmatrix} = \begin{bmatrix} 0 & \beta_{12} & \beta_{13} \\ 0 & 0 & 0 \\ 0 & 0 & 0 \end{bmatrix} \begin{bmatrix} \eta_1 \\ \eta_2 \\ \eta_3 \end{bmatrix} + \begin{bmatrix} \gamma_{11} & 0 & \gamma_{13} & \gamma_{14} & \gamma_{15} & \gamma_{16} \\ \gamma_{21} & \gamma_{22} & \gamma_{23} & \gamma_{24} & \gamma_{25} & 0 \\ \gamma_{31} & \gamma_{32} & 0 & \gamma_{34} & \gamma_{35} & 0 \end{bmatrix} \begin{bmatrix} \xi_1 \\ \xi_2 \\ \xi_3 \\ \xi_4 \\ \xi_5 \\ \xi_6 \end{bmatrix} + \begin{bmatrix} \zeta_1 \\ \zeta_2 \\ \zeta_3 \end{bmatrix} \qquad (6.1\text{-}8)$$

where the η's and the ξ's are endogenous and exogenous variables respectively and the matrix Γ contains the effects of the predetermined variables (x) on the variables (y); and ζ_1, ζ_2, and ζ_3 are errors of equations (disturbance terms).

The matrices for the measurement models consistent with Figure 6.1-4 are:

$$\begin{bmatrix} y_1 \\ y_2 \\ y_3 \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} \eta_1 \\ \eta_2 \\ \eta_3 \end{bmatrix} + \begin{bmatrix} \epsilon_1 \\ \epsilon_2 \\ \epsilon_3 \end{bmatrix} \qquad (6.1\text{-}9)$$

$$\begin{bmatrix} x_1 \\ x_2 \\ x_3 \\ x_4 \\ x_5 \\ x_6 \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} \xi_1 \\ \xi_2 \\ \xi_3 \\ \xi_4 \\ \xi_5 \\ \xi_6 \end{bmatrix} + \begin{bmatrix} \delta_1 \\ \delta_2 \\ \delta_3 \\ \delta_4 \\ \delta_5 \\ \delta_6 \end{bmatrix} \qquad (6.1\text{-}10)$$

where the variables denoted by y's are the observed measures for the η's corresponding to the three endogenous variables. Likewise, the variables denoted by x's are the observed measures for the latent exogenous variables ξ's. Both ϵ and δ as noted before denote errors that correspond to the reliability of measurement. The interpretation of the 1's and 0's has already been presented and follows the same argument (refer to our discussion following equation 6.1-3).

The Φ matrix containing the variance-covariance among the six exogenous variables is a (6x6) matrix of the form presented in equation 6.1-4. Thus,

$$\Phi = \begin{bmatrix} \phi_{11} & 0 & 0 & 0 & 0 & 0 \\ \phi_{21} & \phi_{22} & 0 & 0 & 0 & 0 \\ \phi_{31} & \phi_{32} & \phi_{33} & 0 & 0 & 0 \\ \phi_{41} & \phi_{42} & \phi_{43} & \phi_{44} & 0 & 0 \\ \phi_{51} & \phi_{52} & \phi_{53} & \phi_{54} & \phi_{55} & 0 \\ \phi_{61} & \phi_{62} & \phi_{63} & \phi_{64} & \phi_{65} & \phi_{66} \end{bmatrix} \qquad (6.1\text{-}11)$$

The Ψ and Θ_ϵ pertaining to this model, however, are different from that of the earlier models because of the addition of one more endogenous variable. For the present model, Ψ and Θ_ϵ are (3x3) matrices of the form:

$$\Psi = \begin{bmatrix} \psi_{11} & 0 & 0 \\ 0 & \psi_{22} & 0 \\ 0 & 0 & \psi_{33} \end{bmatrix} \qquad (6.1\text{-}12)$$

$$\Theta_\epsilon = \begin{bmatrix} \theta_{\epsilon 11} & 0 & 0 \\ 0 & \theta_{\epsilon 22} & 0 \\ 0 & 0 & \theta_{\epsilon 33} \end{bmatrix} \qquad (6.1\text{-}13)$$

Finally, the variance-covariance matrix for measurement of the exogenous variables Θ_δ is a (6x6) matrix of the form:

$$\Theta_\delta = \begin{bmatrix} \theta_{\delta 11} & 0 & 0 & 0 & 0 & 0 \\ 0 & \theta_{\delta 22} & 0 & 0 & 0 & 0 \\ 0 & 0 & \theta_{\delta 33} & 0 & 0 & 0 \\ 0 & 0 & 0 & \theta_{\delta 44} & 0 & 0 \\ 0 & 0 & 0 & 0 & \theta_{\delta 55} & 0 \\ 0 & 0 & 0 & 0 & 0 & \theta_{\delta 66} \end{bmatrix} \qquad (6.1\text{-}14)$$

The system of equations presented above specifies the model for interns and residents, general(family) practitioners specialists and a combined model involving the latter two categories of physicians at Time 1. The magnitudes and the signs of the estimated coefficients will be used to test the overall models. It should be noted that the procedure used for these specific cases can be used for any kind of model in order to derive relationships between variables and hence the estimation of the parameters of the models.

6.1.2 Structural and Measurement Components of Models at Time 2

Now let us turn to the specification of models at Time 2, the rules of which are the same as those discussed earlier. In this section, the discussion will be limited to the matrix representation of the theoretical relations between variables for different models, so that the statistical assumptions imposed in specifying the models are not repeated.

Recursive causal models for interns and residents, general(family) practitioners and specialists with a single indicator for each construct are presented in Figures 6.1-5, 6.1-6, and 6.1-7. To summarize the first two models in nontechnical terms, the endogenous variables interns and residents (Figure 6.1-5) and general(family) practitioners (Figure 6.1-6) are affected by CHD, OLD, NAT, EDU, OOD and GEP in addition to being indirectly affected - mediated by BED - by the same variables (excluding NAT) plus an additional variable, POP.

In the third model (Figure 6.1-7), the endogenous variable specialist ratio (SPP) is directly affected by POP, CHD, NAT, EDU, OOD, and GEP and indirectly by all these variables excluding NAT. In equation form, the three models are set forth as follows:

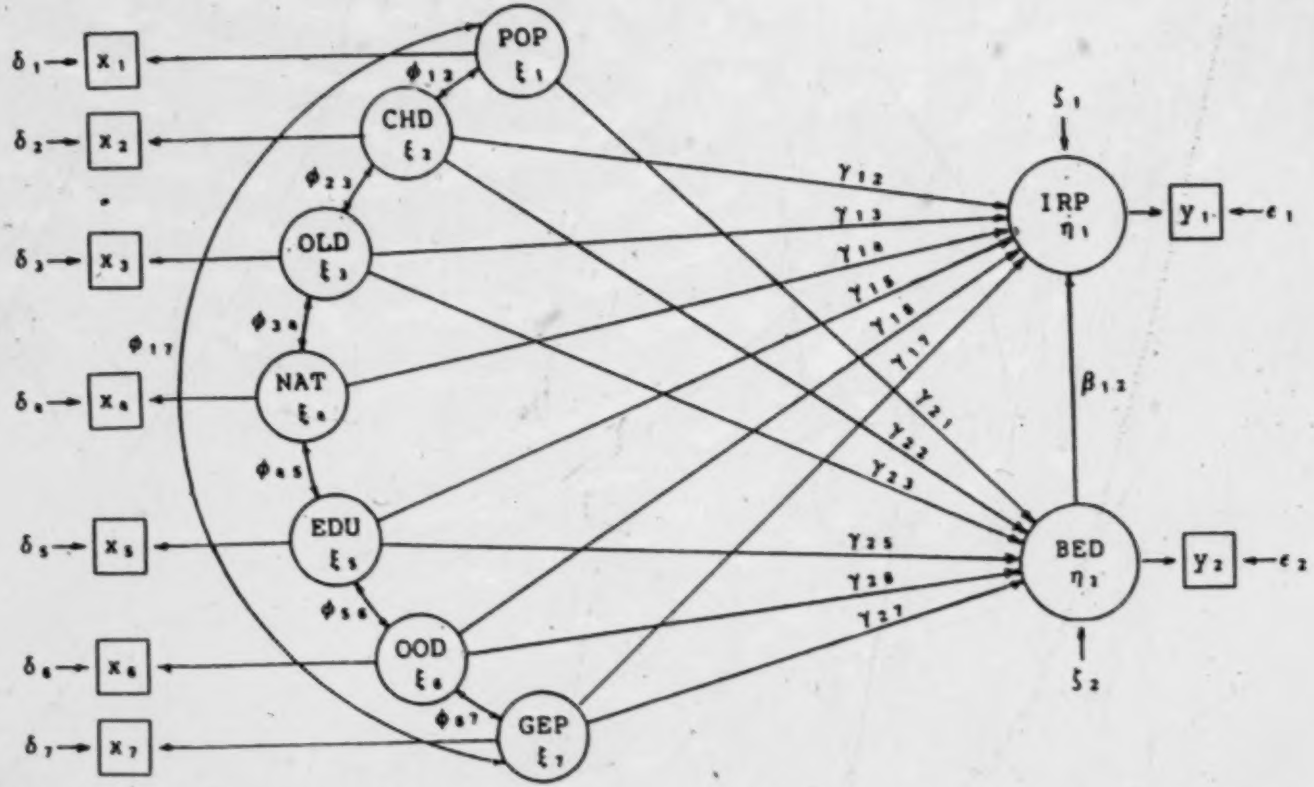

POP
ξ_1
CHD
ξ_2
OLD
ξ_3
NAT
ξ_4
EDU
ξ_5
OOD
ξ_6
GEP
ξ_7
ϕ_{12}
ϕ_{23}
ϕ_{34}
ϕ_{45}
ϕ_{56}
ϕ_{67}
ϕ_{17}
x_1
x_2
x_3
x_4
x_5
x_6
x_7
δ_1
δ_2
δ_3
δ_4
δ_5
δ_6
δ_7
γ_{12}
γ_{13}
γ_{14}
γ_{15}
γ_{16}
γ_{17}
γ_{21}
γ_{22}
γ_{23}
γ_{25}
γ_{26}
γ_{27}
IRP
η_1
BED
η_2
β_{12}
ζ_1
ζ_2
y_1
y_2
ϵ_1
ϵ_2

Figure 6.1-5. The Causal Diagram Describing Effects of Demographic, Socio-economic, Ecological, and Environmental Factors on Interns and Residents Distribution at Time 2

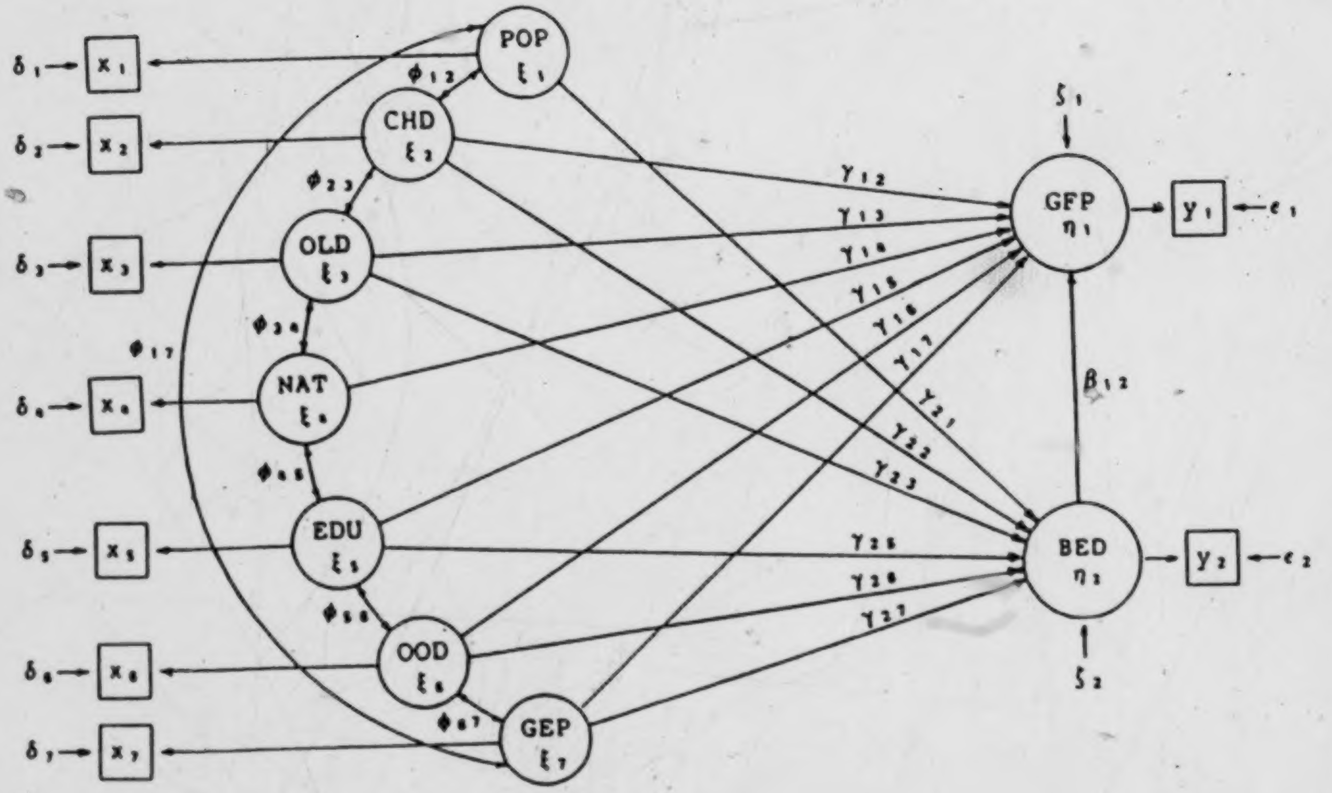

δ_1
x_1
δ_2
x_2
δ_3
x_3
δ_4
x_4
δ_5
x_5
δ_6
x_6
δ_7
x_7
POP ξ_1
CHD ξ_2
OLD ξ_3
NAT ξ_4
EDU ξ_5
OOD ξ_6
GEP ξ_7
ϕ_{12}
ϕ_{23}
ϕ_{34}
ϕ_{17}
ϕ_{45}
ϕ_{56}
ϕ_{67}
γ_{12}
γ_{13}
γ_{14}
γ_{15}
γ_{16}
γ_{17}
γ_{21}
γ_{22}
γ_{23}
γ_{25}
γ_{26}
γ_{27}
ζ_1
GFP η_1
y_1
ϵ_1
β_{12}
BED η_2
y_2
ϵ_2
ζ_2

Figure 6.1-6 The Causal Diagram Describing Effects of Demographic, Socio-economic, Ecological, and Environmental Factors on General (Family) Practitioners Distribution at Time 2

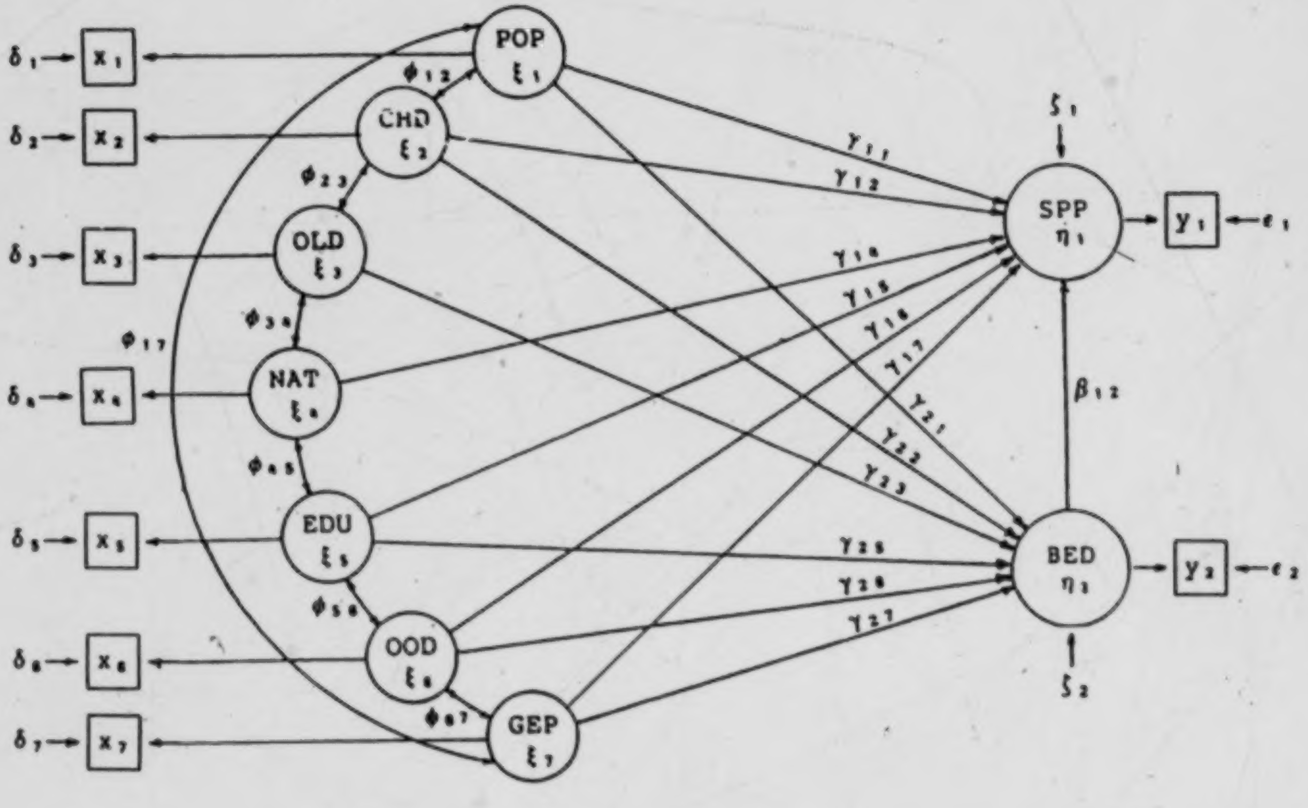

δ1
δ2
δ3
δ4
δ5
δ6
δ7
x1
x2
x3
x4
x5
x6
x7
POP ξ1
CHD ξ2
OLD ξ3
NAT ξ4
EDU ξ5
OOD ξ6
GEP ξ7
φ12
φ23
φ34
φ45
φ56
φ67
φ17
γ11
γ12
γ14
γ15
γ16
γ17
γ21
γ22
γ23
γ25
γ26
γ27
ζ1
ζ2
SPP η1
BED η2
β12
y1
y2
ε1
ε2

Figure 6.1-7 The Causal Diagram Describing Effects of Demographic, Socio-economic, Ecological, and Environmental Factors on Specialists Distribution at Time 2

POP ≡ ξ_1 (ksi sub 1) IRP/GFP/SPP ≡ η_1 (eta sub 1)
CHD ≡ ξ_2 (ksi sub 2) BED ≡ η_2 (eta sub 2)
OLD ≡ ξ_3 (ksi sub 3)
NAT ≡ ξ_4 (ksi sub 4)
EDU ≡ ξ_5 (ksi sub 5)
OOD ≡ ξ_6 (ksi sub 6)
GEP ≡ ξ_7 (ksi sub 7)

$$\begin{bmatrix}\eta_1\\ \eta_2\end{bmatrix} = \begin{bmatrix}0 & \beta_{12}\\ 0 & 0\end{bmatrix}\begin{bmatrix}\eta_1\\ \eta_2\end{bmatrix} + \begin{bmatrix}0 & \gamma_{12} & \gamma_{13} & \gamma_{14} & \gamma_{15} & \gamma_{16} & \gamma_{17}\\ \gamma_{21} & \gamma_{22} & \gamma_{23} & 0 & \gamma_{25} & \gamma_{26} & \gamma_{27}\end{bmatrix}\begin{bmatrix}\xi_1\\ \xi_2\\ \xi_3\\ \xi_4\\ \xi_5\\ \xi_6\\ \xi_7\end{bmatrix} + \begin{bmatrix}\zeta_1\\ \zeta_2\end{bmatrix} \qquad (6.1\text{-}15)$$

where η, B, Γ, ξ and ζ follow the same interpretation as before. For the model in Figure 6.1-7, γ_{13} is zero and γ_{11} is nonzero.

The matrix representations of the measurement models follow the same structure as the models at Time 1 since the number of input variables are equal and the statistical assumptions imposed in specifying the models are the same.

Figures 6.1-8 and 6.1-9 present the combined models designed to investigate the interdependencies among

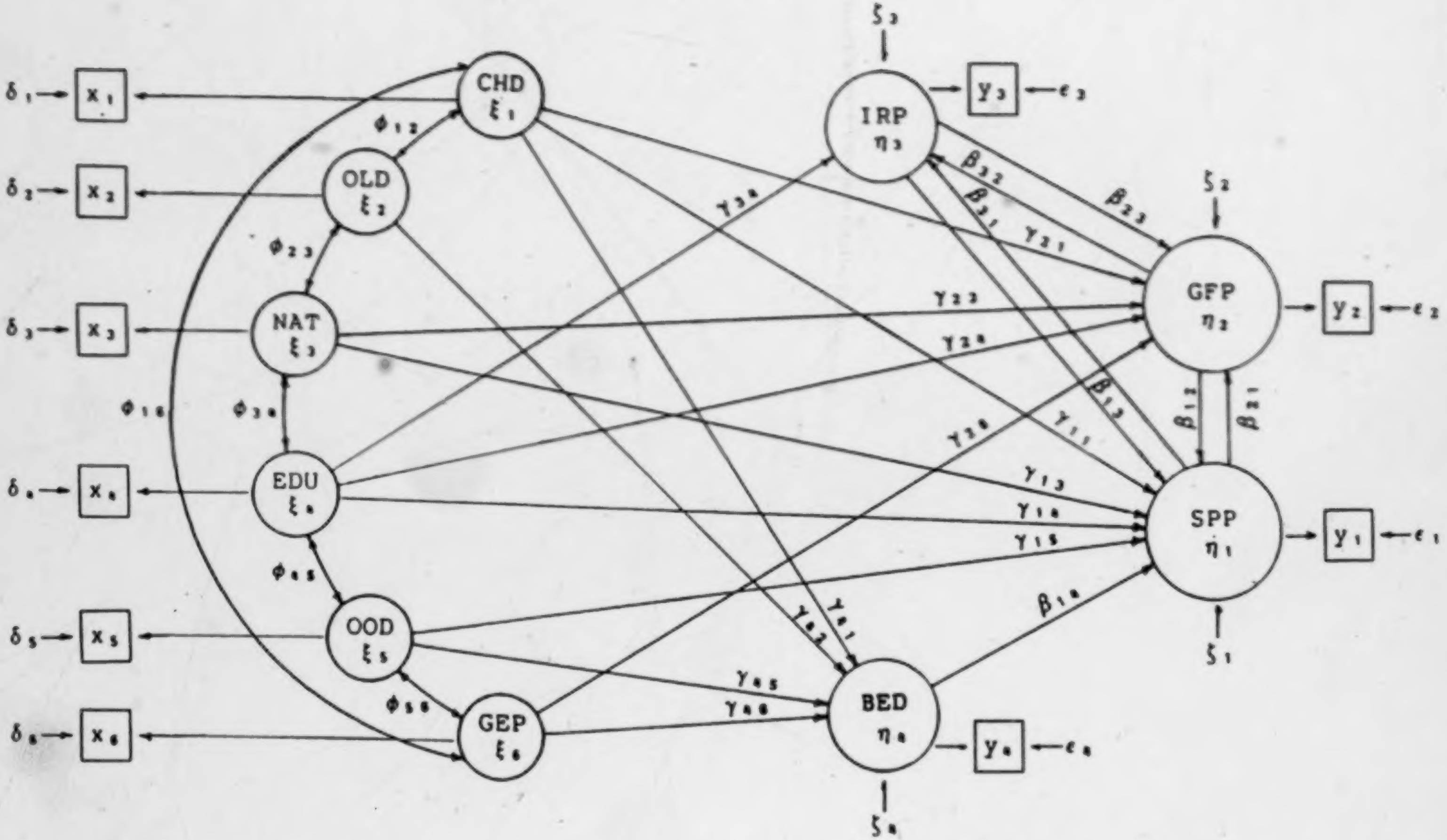

δ_1
x_1
δ_2
x_2
δ_3
x_3
δ_4
x_4
δ_5
x_5
δ_6
x_6
CHD ξ_1
OLD ξ_2
NAT ξ_3
EDU ξ_4
OOD ξ_5
GEP ξ_6
ϕ_{12}
ϕ_{23}
ϕ_{16}
ϕ_{34}
ϕ_{45}
ϕ_{56}
ζ_3
IRP η_3
y_3
ϵ_3
β_{32}
β_{31}
β_{23}
γ_{34}
γ_{21}
ζ_2
GFP η_2
y_2
ϵ_2
γ_{22}
γ_{24}
β_{13}
β_{12}
β_{21}
γ_{26}
γ_{11}
γ_{13}
γ_{14}
γ_{15}
SPP η_1
y_1
ϵ_1
ζ_1
γ_{41}
γ_{42}
β_{14}
γ_{45}
γ_{46}
BED η_4
y_4
ϵ_4
ζ_4

Figure 6.1-8. The Causal Diagram Describing Effects of Demographic, Socio-economic, Ecological, and Environmental Factors on Interns and Residents, General (Family) Practitioners and Specialists Distribution at Time 2

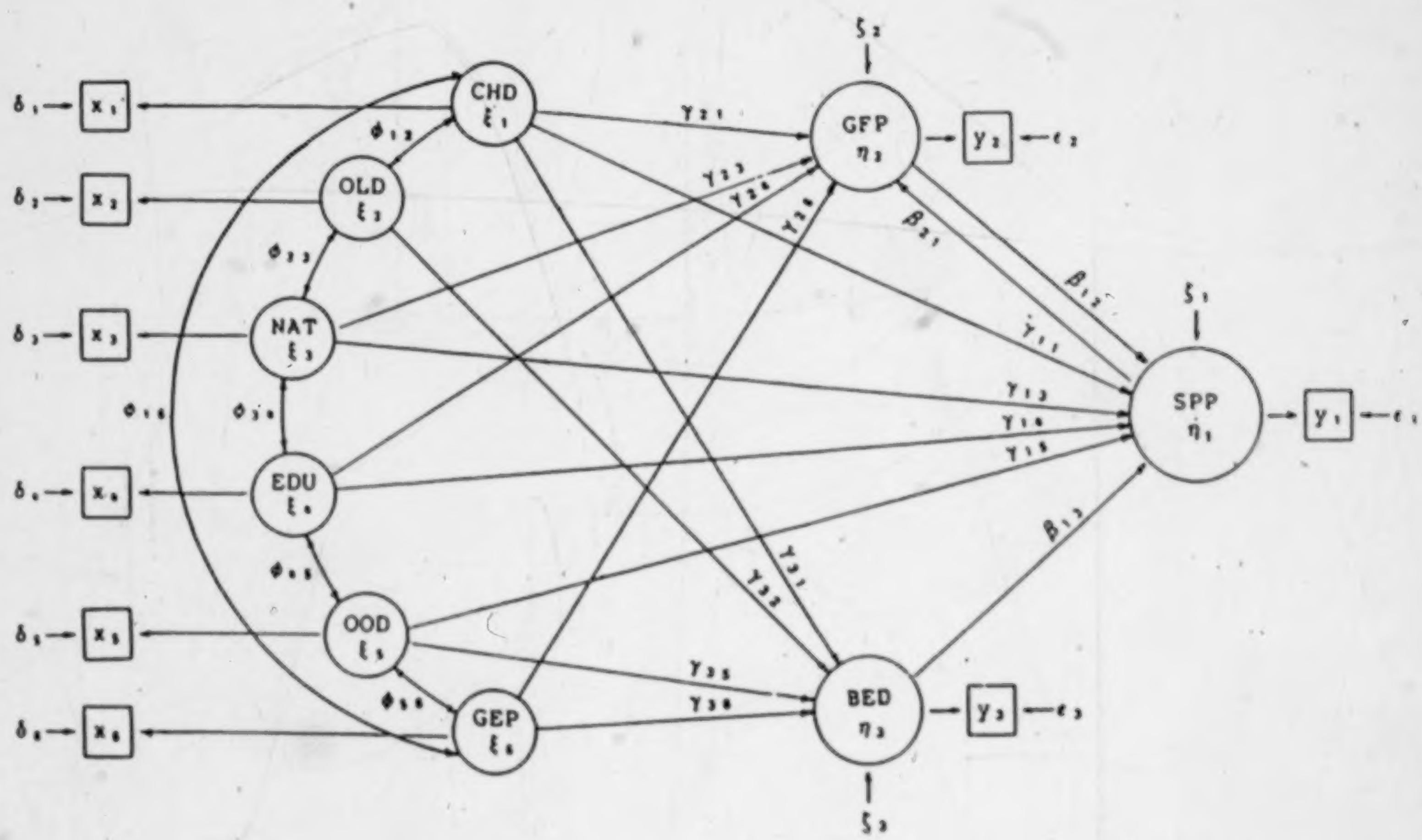

ζ_2
ζ_1
ζ_3
δ_1
x_1
δ_2
x_2
δ_3
x_3
δ_4
x_4
δ_5
x_5
δ_6
x_6
CHD ξ_1
OLD ξ_2
NAT ξ_3
EDU ξ_4
OOD ξ_5
GEP ξ_6
ϕ_{12}
ϕ_{23}
ϕ_{34}
ϕ_{45}
ϕ_{56}
ϕ_{16}
γ_{21}
γ_{23}
γ_{24}
γ_{26}
GFP η_2
y_2
ϵ_2
β_{21}
β_{12}
γ_{11}
γ_{13}
γ_{14}
γ_{15}
SPP η_1
y_1
ϵ_1
β_{13}
γ_{31}
γ_{32}
γ_{35}
γ_{36}
BED η_3
y_3
ϵ_3

Figure 6.1-9 The Causal Diagram Describing Effects of Demographic, Socio-economic, Ecological, and Environmental Factors on General (Family) Practitioners and Specialists Distribution at Time 2

physician categories. The model in Figure 6.1-8 includes all the categories of physicians whereas the model in Figure 6.1-9 excludes interns and residents. As mentioned earlier, the models are restricted by eliminating from each model any path which did not reach the significance level. The following relationships have been hypothesized between the variables (Figure 6.1-8):

1. the endogenous variable specialists is affected by the exogenous variabless, CHD, NAT, EDU, OOD and the endogenous variables general(family) practitioners (GFP), interns and residents (IRP), and hospital beds (BED);
2. the endogenous variable general(family) practitioners is affected by the exogenous variables CHD, NAT, EDU, and GEP and the endogenous variables, specialists and interns and residents;
3. the endogenous variable interns and residents is affected by the exogenous variables EDU and the endogenous variables specialists and general(family) practitioners; and
4. the endogenous variable hospital beds is affected by CHD, OLD, OOD, and GEP.

Accordingly, in Figure 6.1-8, the structural equation model relating the exogenous variables to the endogenous variables can be written as:

CHD ≡ ξ_1 (ksi sub 1)
OLD ≡ ξ_2 (ksi sub 2)
NAT ≡ ξ_3 (ksi sub 3)
EDU ≡ ξ_4 (ksi sub 4)
OOD ≡ ξ_5 (ksi sub 5)
GEP ≡ ξ_6 (ksi sub 6)

SPP ≡ η_1 (eta sub 1)
GFP ≡ η_1 (eta sub 1)
IRP ≡ η_3 (eta sub 3)
BED ≡ η_4 (eta sub 4)

$$\begin{bmatrix}\eta_1\\ \eta_2\\ \eta_3\\ \eta_4\end{bmatrix} = \begin{bmatrix}0 & \beta_{12} & \beta_{13} & \beta_{14}\\ \beta_{21} & 0 & \beta_{23} & 0\\ \beta_{31} & \beta_{32} & 0 & 0\\ 0 & 0 & 0 & 0\end{bmatrix}\begin{bmatrix}\eta_1\\ \eta_2\\ \eta_3\\ \eta_4\end{bmatrix} + \begin{bmatrix}\gamma_{11} & 0 & \gamma_{13} & \gamma_{14} & \gamma_{15} & 0\\ \gamma_{21} & 0 & \gamma_{23} & \gamma_{24} & 0 & \gamma_{26}\\ 0 & 0 & 0 & \gamma_{34} & 0 & 0\\ \gamma_{41} & \gamma_{42} & 0 & 0 & \gamma_{45} & \gamma_{46}\end{bmatrix}\begin{bmatrix}\xi_1\\ \xi_2\\ \xi_3\\ \xi_4\\ \xi_5\\ \xi_6\end{bmatrix} +$$

$$\begin{bmatrix}\zeta_1\\ \zeta_2\\ \zeta_3\\ \zeta_4\end{bmatrix} \qquad (6.1\text{-}16)$$

The basic structure of the measurement models parallels that of the model in Figure 6.1-4. The only exceptions are:

$$\begin{bmatrix}y_1\\ y_2\\ y_3\\ y_4\end{bmatrix} = \begin{bmatrix}1 & 0 & 0 & 0\\ 0 & 1 & 0 & 0\\ 0 & 0 & 1 & 0\\ 0 & 0 & 0 & 1\end{bmatrix}\begin{bmatrix}\eta_1\\ \eta_2\\ \eta_3\\ \eta_4\end{bmatrix} + \begin{bmatrix}\epsilon_1\\ \epsilon_2\\ \epsilon_3\\ \epsilon_4\end{bmatrix} \qquad (6.1\text{-}17)$$

$$\Psi = \begin{bmatrix} \psi_{11} & 0 & 0 & 0 \\ \psi_{21} & \psi_{22} & 0 & 0 \\ \psi_{31} & \psi_{32} & \psi_{33} & 0 \\ 0 & 0 & 0 & \psi_{44} \end{bmatrix} \tag{6.1-18}$$

$$\Theta_\epsilon = \begin{bmatrix} \theta_{\epsilon 11} & 0 & 0 & 0 \\ 0 & \theta_{\epsilon 22} & 0 & 0 \\ 0 & 0 & \theta_{\epsilon 33} & 0 \\ 0 & 0 & 0 & \theta_{\epsilon 44} \end{bmatrix} \tag{6.1-19}$$

Note that ψ_{21}, ψ_{31}, and ψ_{32} indicating correlations between construct residuals ζ_1, ζ_2, and ζ_3 are set free in this model. This means that some variables (or combination of variables) have been omitted from the equations for specialists, general(family) practitioners and interns and residents.

The above relationships are further examined in a restricted framework as diagrammed in Figure 6.1-9. Although there are certain important distinctions between the models in Figures 6.1-8 and 6.1-9, the paths between the exogenous variables and the endogenous variables, specialists (η_1), general(family) practitioners (η_2) and hospital beds (η_3) are identical (BED becomes η_3 in the absence of IRP). In other words, these endogenous variables are affected by the same exogenous variables in both the models. The model assumes reciprocal effects between the two physician categories. Finally, hospital beds (η_3) is hypothesized to have a direct effect on specialists (η_1).

The structural equations for this model in the matrix form may be written as:

$$\begin{bmatrix}\eta_1\\ \eta_2\\ \eta_3\end{bmatrix} = \begin{bmatrix}0 & \beta_{12} & \beta_{13}\\ \beta_{21} & 0 & 0\\ 0 & 0 & 0\end{bmatrix}\begin{bmatrix}\eta_1\\ \eta_2\\ \eta_3\end{bmatrix} + \begin{bmatrix}\gamma_{11} & 0 & \gamma_{13} & \gamma_{14} & \gamma_{15} & 0\\ \gamma_{21} & 0 & \gamma_{23} & \gamma_{24} & 0 & \gamma_{26}\\ \gamma_{31} & \gamma_{32} & 0 & 0 & \gamma_{35} & \gamma_{36}\end{bmatrix}\begin{bmatrix}\xi_1\\ \xi_2\\ \xi_3\\ \xi_4\\ \xi_5\\ \xi_6\end{bmatrix} + \begin{bmatrix}\zeta_1\\ \zeta_2\\ \zeta_3\end{bmatrix} \tag{6.1-20}$$

For the Model,

$$\Psi = \begin{bmatrix}\psi_{11} & 0 & 0\\ \psi_{21} & \psi_{22} & 0\\ 0 & 0 & \psi_{33}\end{bmatrix} \tag{6.1-21}$$

ψ_{21} is set free in this equation, it implies that there are common variances omitted from the equations for each of the endogenous variables: general(family) practitioners and specialists.

In the discussion above, the theoretical relations between variables are translated into diagrams and/or equations. Once the models have been specified, it is possible to test the hypothesized models using the data at hand. More to the point, the unknown parameters of the models are estimated to make the variances and covariances that are implied by the models to approximate the observed data. This topic is taken up in considerable detail in sections 6.2 and 6.3 that follow. The discussion will provide empirical evidence to support or reject the various hypotheses stated above.

Before concluding this section, some comments need to be made about the measurement structure of variables. The modelling strategy that has been adopted in the analysis refers to both structural and measurement components that characterize the causal system under study. It is therefore important to gather as much information as posssible on likely errors of measurement in both the endogenous and exogenous variables. For the models, all the values of Θ_ϵ and Θ_δ - the variance-covariance matrices of errors of measurement of endogenous (y's) and exogenous (x's) variables - are fixed to include a specific proportion of the variance in each indicator as measurement error variance, with the remaining variance being left to the corresponding underlying concept. This provides an opportunity to have some direct control over the meaning of the concepts although from a methodological standpoint, one may argue that this is not an efficient procedure. It is, often advisable to adopt a two-stage procedure in which the measurement model is estimated first and the estimates obtained are then included as fixed parameters in the second stage in estimating the structural model. In the present analyses, however, the structural and the measurement models (with parameters fixed) are estimated simultaneously.

As earlier stated, the models estimated in the present study include a single indicator for each latent construct. When one indicator is used for a given construct, neither the relationship of the indicator variable to the latent construct nor the error variance for the observed variable may be estimated meaningfully (Ladewig and McGee, 1986). For these variables, error variance estimates were constrained to specific values $(1 - \alpha SD^2)$ as recommended by Jöreskog and Sörbom (1982), to provide an approximation of the amount of error in that measure.

6.2 Model-Fitting and Discussion of Results: Models at Time 1

Having formulated the relationship between the theoretical constructs, we shall now discuss the results of analyses of the data starting with Time 1 models. Parameter estimation and discussion of the estimates of the models presented in Figures 6.1-1 through 6.1-4 are the major tasks of this section. The discussion will include a detailed examination of the fit of the models and interpretation of the standardized solutions, allowing comparisions of the different effects of variables. The first model is discussed in somewhat greater detail describing the different procedures to test models.

6.2.1 Interns and Residents Model at Time 1

We focus attention first on goodness-of-fit statistics for the model specified in Figure 6.1-1. Then we discuss the parameter estimates for the model, interpreting the results in light of the hypotheses stated before. The input variance-covariance matrix of the model is presented in Appendix Table A-1. Given this information, LISREL VI computer program is used to estimate the parameters and to test the goodness-of-fit (see Jöreskog and Sörbom, 1986).

The maximum likelihood method is used to obtain estimates of the model parameters. Although the specific form of the likelihood function is not important at this point, the basic requirements should be noted:

1. the observed variance-covariance matrix should be positive definite; and
2. the starting values for the parameter estimates should be provided such that the fitted variance-covariance matrix (Σ) is also positive definite.

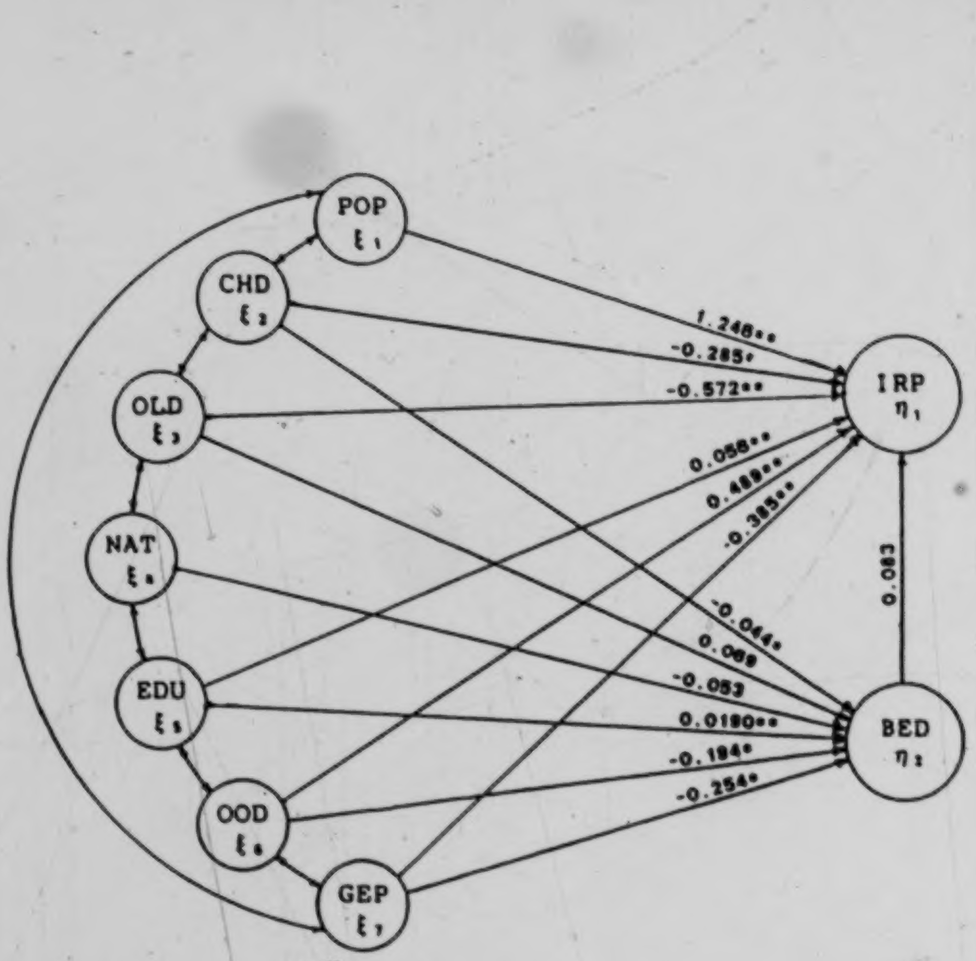
First, we must check whether the model in Figure 6.1-1 is consistent with the data. Obviously, the simplest method is to examine the chi-square value associated with the goodness-of-fit test. The test of chi-square is similar to any other null hypothesis test in statistics. Thus, a small value of chi-square corresponding to a *p* value close to 1.0 indicates that the model fits the data very well. Conversely, if the chi-square is large compared to degrees of freedom (and a small value of *p*), one can conclude that the model does not appropriately mirror the causal process that produced the observed covariance.

The chi-square test of goodness-of-fit is not without limitations. One problem is that the value of the statistic depends on the sample size. Thus, if very large samples are used, any hypothesized model could be rejected by the chi-square test. Unfortunately, no standard methodology exists for interpreting goodness-of-fit as reflected by chi-square values. As with any multivariate analysis, a reasonable rule to estimate the appropriate sample size is that it be five to twenty-five times the number of observed variables (Rindskopf, 1981:180). The goodness-of-fit of a model to data in any instance should be evaluated by methods such as residual analysis beside the chi-square static, as will be discussed later.

The maximum likelihood estimates computed by LISREL for the interns and residents model are presented in Figure 6.2-1 and Table 6.2-1. Table 6.2-1 also presents the goodness-of-fit measures.

The fit of the model is very good: $\chi^2 = 0.64$ with 2 degrees of freedom ($P = 0.725$). This suggests that the parameter estimates which have been obtained are very informative for the causal process under discussion.

Two alternative measures of overall fit are the root mean square residual (RMSR) and goodness-of-fit index (GFI). The root mean square residual can be used to compare the fit of two different models using the same data. The goodness-of-fit index can be used to compare models for the same data set but can also be used to compare models for different data sets. The advantage of this measure is that it is easier to interpret than RMSR.



POP
ξ_1
CHD
ξ_2
OLD
ξ_3
NAT
ξ_4
EDU
ξ_5
OOD
ξ_6
GEP
ξ_7
IRP
η_1
BED
η_2
1.248**
-0.285*
-0.572**
0.058**
0.489**
-0.385**
-0.044*
0.069
-0.053
0.0180**
-0.194*
-0.254*
0.083

Figure 6.2-1. A Causal Diagram of the Interns and Residents Model at Time 1 with Standardized Parameters as Estimated by LISREL

* Parameter is more than 1.5 times its standard error

** Parameter is more than twice its standard error

Table 6.2-1

Metric and Standarized[1] Structural Coefficients and Goodness-of-Fit Measures for the Intern and Resident Model at Time 1

	IRP	BED	POP	CHD	OLD	NAT	EDU	OOD	GEP
IRP	0.000* (0.000)	0.159 (0.083)	24.536 (1.246)	-26.847 (-0.285)	-13.298 (-0.572)	0.000* (0.000)	1.526 (0.056)	3.836 (0.489)	-0.234 (-0.385)
BED	0.000* (0.000)	0.000* (0.000)	0.000* (0.000)	-2.163 (-0.044)	0.837 (0.069)	-1.036 (-0.053)	0.273 (0.019)	-0.796 (-0.194)	-0.081 (-0.254)
R^2	0.972	0.108							
PSI	0.028	0.892							

χ^2=0.64 D. F.=2 P=0.725 GFI=0.998 AGFI=0.945 RMSR=41.301 Max NR=0.519 Max MI=0.64**

R^2 = Squared Multiple Correlations for Structural Equations
PSI = Covariances among the ζ Error Terms
χ^2 = CHI Square
D. F. = Degrees of Freedom
GFI = Goodness-of-Fit Index
AGFI = Adjusted Goodness-of-Fit Index
RMSR = Root Mean Square Residual Correlation
Max NR = Maximum Normalized Residual
Max MI = Maximum Modification Index

[1] Standardized Coefficients in parentheses
* The parameter is constrained to zero.
** Warrants no further reduction of constraints in the Model is needed.

If GFI is zero the fit is bad, if it is close to 1 the fit is good. For the model, GFI = 0.998, which indicates a good fit.

LISREL programme also yields a measure of fit - the adjusted goodness-of-fit index (AGFI) - which takes into account the number of degrees of freedom. This measure also lies in principle between values 0 and 1 where 0 indicates a very bad fit and 1 a very good fit. For the model AGFI = 0.945, indicating a good fit.

A good statistical fit, however, is only one of the criteria for assessing model accuracy. It is possible that models different from the one specified could fit the data as well or better. It should also be mentioned that the sample size of 59 is not large enough to warrant the use of χ^2 as a test statistic. Therefore several criteria, in addition to goodness-of-fit measures, can be used to ascertain the "best" model. LISREL computer program provides the following diagnostic procedures for correcting models.

(a) The *residual* variance-covariance matrix (the difference between the predicted and actual value of each variance or covariance) can indicate for which variables large discrepancies exist between theory and observation. A general rule is that if all the *residuals* are less than 2.0 in absolute value, the model is good, the smaller the better (Jöreskog and Sörbom, 1986). An advantage of this method is that it does not depend on sample size.

(b) *Q-plot of the normalized residuals* (a plot of the normalized residuals against normal quantiles) which again point to the descrepancies between the observed covariances and those implied by the model (not included in our discussion). If the slope of the straight line joining the ploted points as compared with the 45-degree line is larger than one, this is an indication of a good fit. Slopes which are smaller than one correspond to poor fits.

(c) *First-order partial derivatives of the fit functions* are evaluated for each fixed as well as constrained parameter. These can be used to know where the function is fitting poorly and may suggest whether or not a particular constraint should be relaxed. If the model is correct, all derivatives must be zero. Conversely, if the model is incorrect, large deviations from zero can occur for some fixed parameters. One can relax the restriction on the particular parameter with the highest derivative (in absolute value) to improve the model.

(d) *Modification indices* are evaluated for each fixed parameter in the model. For each parameter which is fixed, there is a modification index equal to the expected decrease in χ^2 if this single parameter *alone* is relaxed. If a modification index corresponding to a fixed parameter is zero it means that the particular parameter will not be identified if it is set free. A practical procedure, suggested by Jöreskog and Sörbom (1986) is that if the modification index for a fixed parameter is larger than 5.0, the model should be reestimated by freeing the parameter.

(e) *Impossible parameter estimates (or so-called Heywood cases in factor analysis)* such as negative variances indicate specification errors in the model. Estimates can be unreasonable for several reasons such as inaccurate data, theory and sampling variability. A common procedure for circumventing the problem, is to fix the variance to zero and reestimate the model (Fornel, 1983:445). This approach has, however, both theoretical and practical flaws (see Fornel, 1983 for details). Also, in some instances, it has been suggested to estimate the square roots of some parameters and then square them to avoid negative variance (Jöreskog, 1981).

(f) *Standard errors for estimated parameters* can be used to provide an indication that some variables are important to the model as a whole. The importance of a parameter to the model is judged on the basis of critical ratios as obtained by dividing the estimate by its standard error. If the ratio is large (i.e., larger than 2.00), the parameter is essential to the model; if it is small, the parameter is probably unnecessary to the model.

The fit of the model in Figure 6.2-1 is further evaluated using the six diagnostic criteria listed above. The first four of these criteria suggest that no constraint need be relaxed. As indicated by Appendix Table A-2, for the most part, the residuals are small, suggesting that the model fits the data well (all residuals are less than 2.0 in magnitude). Also, the first-order derivatives of all the constrained parameters are zero indicating a good fit (Appendix Table A-3).

As can be seen from Table 6.2-4 the modification index associated with γ_{21} is the largest of all (0.64). This result suggests that γ_{21} (the path from population size to hospital beds), which was fixed at zero, will lead to a reduction in value of the χ^2 by 0.64 if the restriction is relaxed. The value, however is insignificant. In other words, the decision to omit the path appears to be well justified.

Another way of describing the fit is to note that the exogenous constructs explain 97% of the variation in interns and residents and approximately 11% of the variation in hospital beds (Table 6.2-1). In other words, factors not considered in the model account for 3% of the variation in interns and residents and 89% of the variation in hospital beds.

Table 6.2-1 also presents the values obtained for the parameters (both metric and standardized) by the maximum likelihood method. The LISREL program provides the standard errors and the T-values for all the estimated parameters of the model (not shown in the Table). Before proceeding to a discussion of the parameter estimates, some important points regarding the use of standardized (unstandardized) solutions should be mentioned.

The advantage of the unstandardized solution is that it permits one to explain the effects of different variables in the original measurement units, and that predictions for the endogenous constructs can be computed, taking into account the value of the intercept (Saris and Stronkhorst, 1984: 255). The disadvantage, however, is that it is difficult to compare the sizes of the coefficients when they are computed for variables which have been expressed in different measurement units. In such instances, the standardized solutions are preferred, since all variables are expressed in the same units (i.e. standard deviations), and the effect indicates the change in the effect variable, expressed in standard deviations, caused by a change of one standard deviation in the causal variable, thereby keeping all the other variables in the equation constant (Saris and Stronkhorst, 1984: 256). To put it differently, for variables having an arbitrary scale within a single population, the relative causal importance of any variable can be assessed through the standardized coefficients; however, for comparisons among populations, unstandardized coefficients are to be used (Acock and Fuller, 1985; Namboodiri et al. 1975). On the basis of this interpretation, the discussion of the relative importance of variables between any two groups of physicians is based on the unstandardized coefficients (whenever the variables are in the same measurement units) and within a single group of physicians, is based on standardized coefficients.

A standardized solution in which the original solution is rescaled so that all the underlying factors have a standard deviation of 1.0, also is valuable in that it provides a better way of interpreting the Φ matrix in terms of correlations between exogenous variables instead of covariances. Table 6.2-2 presents these correlations. We note a moderately strong correlation between POP and EDU (0.565); POP and OOD (-0.555); and EDU and OOD (-0.547). However, OOD is nearly independent of the age structure of the population and is positively related to

Table 6.2-2

PHI Matrix (Covariance Matrix of Exogenous Variables) for the Interns and Resident Model at Time 1

	POP	CHD	OLD	NAT	EDU	OOD	GEP
POP	1.000						
CHD	-0.215	1.000					
OLD	0.228	-0.482	1.000				
NAT	-0.114	0.239	0.099	1.000			
EDU	0.565	0.032	0.134	-0.083	1.000		
OOD	-0.555	0.173	0.229	0.340	-0.547	1.000	
GEP	0.280	-0.124	-0.056	0.019	-0.011	-0.161	1.000

both the age groups. The positive correlation means that areas where the two age groups are overrepresented also have large proportions of owner occupied dwellings. A low but negative relationship between GEP and OOD is also noted.

Turning to the effects of exogenous variables on the endogenous variable, interns and residents, it can be seen that the parameter estimates are not all in agreement with the expectations (Figure 6.2-1 and Table 6.1-1). CHD and OLD have negative effects on interns and residents; interns and residents are fewer in areas where the two age-groups are over-represented. This is an unexpected finding in the light of previous work but is consistent with the regression results. Apparently, the working of these compositional predictors are in no way peculier to interns and residents, as will be seen later in this chapter. These results need more testing before an adequate interpretation can be given. As expected, POP and OOD have positive effects and GEP has a negative effect on interns and residents.

As Figure 6.2-1 indicates, all the exogenous variables with the exception of EDU have significant effects on interns and residents (IRP). The effect of the endogenous variable BED on interns and residents (IRP) is positive as expected although it is statistically insignificant (0.083).

If we consider the effect of exogenous variables on BED, it is evident that GEP is the single efficient variable affecting BED; the greater the distance of an area from a metropolitan area, the fewer the hospital beds in the area (-0.254). All the variables with the exceptions of CHD and OOD have signs in the expected direction. Although not statistically significant, the second most important variable having a direct effect on hospital beds is OOD (-0.194).

Figure 6.2-1 underlines that one should not concentrate only on the direct effects between variables when interpreting the causal structure. The composition effects of variables are presented in Table 6.2-3. The total effects of variables are almost equal to the direct effect since their indirect effects are minimal. GEP is the variable with the largest indirect effect (-0.021). An examination of the total effects also indicates that compared to other variables, NAT and EDU do not have much effect on interns and residents.

The findings presented in Table 6.2-3 indicate that intern and resident physicians are highly concentrated in urban centres. According to the computed total effects, it is also very clear that interns and residents are few in

Table 6.2-3

Decomposition Effects of Endogenous and Exogenous Variables for the Interns and Residents Model at Time 1'

Variables	IRP			BED
	Direct	Indirect	Total	Direct(Total)
IRP	0.000*	0.000*	0.000*	0.000*
BED	0.083	0.000*	0.083	0.000*
POP	1.246	0.000*	1.246	0.000*
CHD	-0.285	-0.004	-0.289	-0.044
OLD	-0.572	0.006	-0.566	0.069
NAT	0.000*	-0.004	-0.004	-0.053
EDU	0.056	0.002	0.058	0.019
OOD	0.489	-0.016	0.473	-0.194
GEP	-0.385	-0.021	-0.406	-0.254

' These are standardized coefficients.
* The parameters are constrained to zero.

remote areas (i.e., areas farther from a metropolitan area). Also, the results indicate that the presence of large proportions of young and old age groups does not mean a large supply of interns and residents; these variables have also quite large effects on the distribution of interns and residents. Certainly, there is some indication that the supply of physicians, and in particular interns and residents is not according to the demand for their services. Thus, rather than concluding that young and old populations predict low physician ratios, it seems more appropriate to conclude that age-structure of the population is not justly linked as far as certain categories of physicians are concerned. Inspection of the direct effects extends this argument, but only a slight difference in physician ratios can be expected between areas based on the educational level of the population.

It appears that development of programmes that will encourage intern and resident physicians to locate in underserviced areas, requires the identification and understanding of factors other than socio-cultural characteristics of areas. Finally, it is also clear that it does not help much in attracting interns and residents by setting up more hospital beds in the area because hospital beds has only a very small effect on the whole process. These arguments will be amplified further when the distribution of interns and residents at Time 2 are considered.

But there are several reasons for being cautious about these results. First, they are based on inaccurate data on interns and residents. Second, the fact that interns and residents are more constrained geographically than other physician groups presents a major disadvantage of rural areas in attracting and retaining this group of physicians. In other words, as long as factors (e.g., educational opportunities) influencing the distribution of interns and residents are not appreciably altered, successful efforts to redistribute interns and residents should focus on the medical education system. Few would disagree with Mejia (1978:38) when he said that, "Ideally health manpower production should be under the control of the education system but should be given guidance by the health manpower planners to ensure that it meets the needs of the health delivery system." This view conforms to Katz's (1978:145) conclusion that "because planners and producers have reciprocal roles, the need for the constant co-ordination and integration of activities is stressed." In any case, our results should be replicated with accurate data before they can be regarded as totally conclusive.

A final note on this analysis is necessary. Although the overall fit of the model to the data is adequate, one might note that the parameter estimate for the variable population size is out of range (i.e. standardized coefficient is larger than unity). As we mentioned earlier, a number of reasons such as inaccurate data/theory and sampling variability may account for such improper estimates (see Fornell, 1983; and Kenny, 1979 for details). Since the path coefficients are, in most cases, in the expected direction and are justified on theoretical grounds, and also because the sample size is relatively small further formulation of this model to confirm the relationships found here is felt unnecessary. As already mentioned, given the inaccuracy of data, acceptance of this model as an appropriate representation of a process underlying interns and residents distribution will certainly require replication of findings in another sample of better quality.

6.2.2 General (Family) Practitioners Model at Time 1

This section will focus on parameter estimation of general practitioners and family physicians model diagrammed in Figure 6.1-2. Included is a discussion of the overall fit and explanatory fit of the model and model coefficients.

The observed variance-covariance matrix which was used as input is presented in Appendix Table A-5. Figure 6.2-2, and Table 6.2-4 present a summary of the maximum likelihood parameter estimates using LISREL computer program. The model provides a statistically perfect fit to the data ($\chi^2 = 1.43$, d.f = 2, P = 0.489). Thus the observed patterns of the variance-covariance matrix conform to those predicted by the model. As illustrated in Appendix Table A-6, the estimated parameters perfectly reconstruct the variances and covariances of the variables within the context of the model; maximum value of the normalized residual is 0.765. The modification index associated with β_{21} (i.e., the effect of general practitioners and family physicians on hospital beds) is the highest of all (1.25). This value is insignificant and indicates that the model is well justified.

The exogenous variables explain 66% of the variation in general practitioners and family physicians whereas they explain only 10% of the variation in hospital beds (Table 6.2-4). We may interpret these findings to indicate that the model of general practitioners and family physicians, although capturing some important aspects of the process, still ignores numerous factors which may explain the distribution of hospital beds and consequently some of the important indirect effects on the ultimate

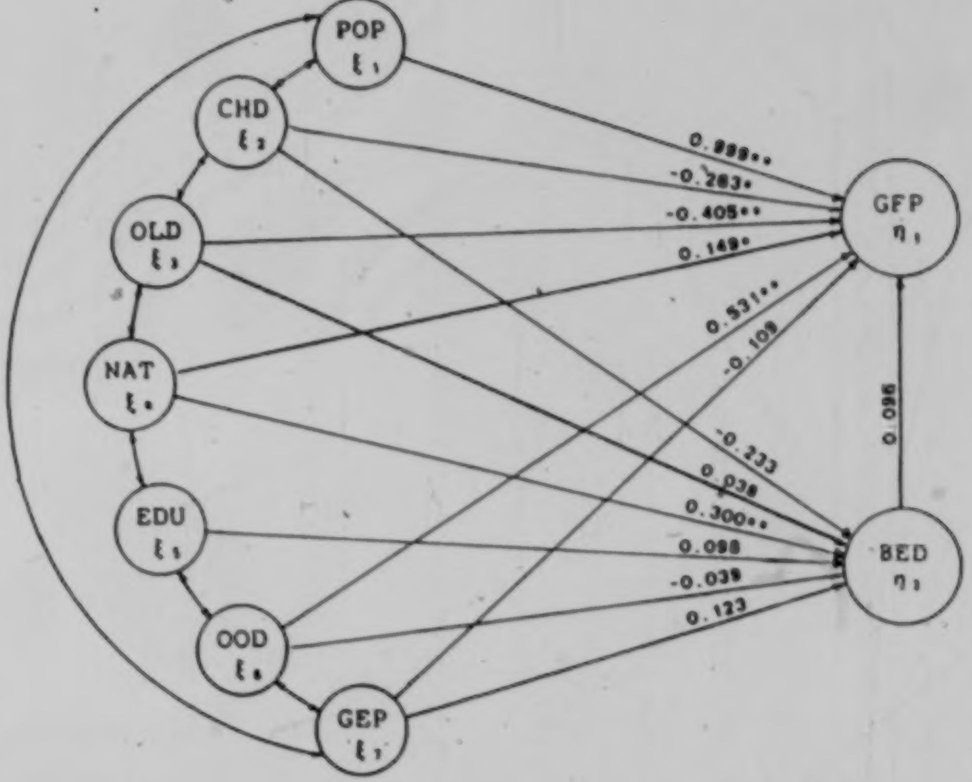

POP ξ_1
CHD ξ_2
OLD ξ_3
NAT ξ_4
EDU ξ_5
OOD ξ_6
GEP ξ_7
GFP η_1
BED η_2
0.899**
-0.283*
-0.405**
0.149*
0.531**
-0.109
-0.233
0.038
0.300**
0.098
-0.039
0.123
0.096

Figure 6.2-2 The Causal Diagram of the General (Family) Practitioners Model at Time 1 with Standardized Parameters as Estimated by LISREL

* Parameter is more than 1.5 times its standard error
** Parameter is more than twice its standard error

Table 6.2-4

Metric and Standarized' Structural Coefficients and Goodness-of-Fit Measures for the General (Family) Practitioners Model at Time 1

	GFP	BED	POP	CHD	OLD	NAT	EDU	OOD	GEP
GFP	0.000* (0.000)	0.141 (0.096)	26.690 (0.999)	-10.803 (-0.263)	-8.539 (-0.405)	1.757 (0.149)	0.000* (0.000)	3.358 (0.531)	-0.046 (-0.109)
BED	0.000* (0.000)	0.000* (0.000)	0.000* (0.000)	-6.494 (-0.233)	0.542 (0.038)	2.404 (0.300)	1.665 (0.098)	-0.169 (-0.039)	0.035 (0.123)
R^2	0.657	0.098							
PSI	0.343	0.902							

χ^2=1.43 D. F.=2 P=0.489 GFI=0.998 AGFI=0.966 RMSR=20.321 Max NR=0.765 Max MI=1.25**

R^2 = Squared Multiple Correlations for Structural Equations
PSI = Covariances among the ζ Error Terms
χ^2 = CHI Square
D. F. = Degrees of Freedom
GFI = Goodness-of-Fit Index
AGFI = Adjusted Goodness-of-Fit Index
RMSR = Root Mean Square Residual Correlation
Max NR = Maximum Normalized Residual
Max MI = Maximum Modification Index

' Standardized Coefficients in parentheses
* The parameter is constrained to zero.
** Warrants no further reduction of constraints in the Model is needed.

dependent variable.

The magnitude of the links between the exogenous variables, presented in Table 6.2-5, indicate that both OLD and GEP have sizable correlations (-0.606 and 0.578 respectively) with CHD. These findings indicate that areas farther away from a metropolitan area are characterized by relatively higher proportions of children under 5 years and such areas have smaller proportions of older population. Surprisingly, POP and GEP are unrelated (0.034). The lack of correlation between POP and GEP may be explained as due mainly to a greater percentage of the urban population in the country. In other words, it points to the fact that the urban-rural differences are narrowing with regard to population size. The relationship between POP and OOD is moderate and is in the expeced direction (-0.493). In this case, highly populated areas have smaller proportions of owner-occupied dwellings. This is understandable given the fact that most residential areas are farther away from major cities.

Figure 6.2-2 gives the standardized coefficients and Table 6.2-4 presents the metric and standardized coefficients of the estimates. Turning to the effects of exogenous variables on general(family) practitioners, there are five significant predictors: POP (0.999), CHD (-0.263), OLD (-0.405), NAT (0.149) and OOD (0.531). The

Table 6.2-5

PHI Matrix (Covariance Matrix of Exogenous Variables) for the General (Family) Practitioners Model at Time 1

	POP	CHD	OLD	NAT	EDU	OOD	GEP
POP	1.000						
CHD	-0.097	1.000					
OLD	0.053	-0.606	1.000				
NAT	-0.083	0.524	-0.147	1.000			
EDU	0.495	-0.016	-0.024	-0.029	1.000		
OOD	-0.493	0.066	0.433	0.027	-0.499	1.000	
GEP	0.034	0.578	-0.315	0.371	-0.056	-0.015	1.000

variable POP is related strongly and positively to the distribution of general practitioners and family physicians. Owner-occupied dwellings, an indicator of economic prosperity also explains the supply of general practitioners and family physicians in an area. As noted in the exploratory analysis, the direct effects of CHD and OLD on general practitioners and family physicians are negative suggesting that areas with large proportions of young and old age-groups tend to have fewer general(family) practitioners.

As far as the effect of BED is concerned it is evident that those areas having a large supply of hospital beds are likely to have large number of general(family) practitioners (0.096).

Native population is the most important predictor (0.300) of BED (Table 6.2-4). Not surprisingly, EDU is positively related to hospital beds (0.098). But contrary to our expectation, CHD and OOD have negative effects and NAT has a positive effect on BED. In other words, the assumption that having a large proportion of natives in an area could deter physicians in choosing their practice location and also minimize the chances of having good hospital facilities is not supported. The finding is, however, consistent with the argument that a higher proportion of owner-occupied dwellings are found in remote areas whereas hospitals are found more in and around cities indicating the regressive nature of physician supply in relation to demand. If this is correct, the effect of geographic proximity on hospital beds should be negative, but the pattern is just the opposite. To repeat an argument made earlier, a low level of urban-rural disjunction seems to exist between areas. Also, as indicated by the findings, there are no significant differentials in population size between areas.

Table 6.2-6 presents the total effects of variables on hospital beds and general practitioners and family physicians, partitioned into direct and indirect effects. Examination of these effects shows that none of the variables have their total effects significantly greater (lower) than their direct effects, because their indirect effects via hospital beds are minimal. However, judging from the indirect effects, one can conclude that a large supply of hospital beds exists in areas where the proportion of the native poulation is large and the proportion of the population under 5 years of age is small. The fact that a large proportion of owner-occupied dwellings is present at the periphery of large cities, combined with the lesser numerical representation of hospitals in such regions explains the negative ~~impact of~~ owner-occupied dwellings on general(family) practitioners

Table 6.2-6

Decomposition Effects of Endogenous and Exogenous Variables for the General (Family) Practitioners Model at Time 1'

Variables	GFP			BED
	Direct	Indirect	Total	Direct(Total)
GFP	0.000*	0.000*	0.000*	0.000*
BED	0.096	0.000*	0.096	0.000*
POP	0.999	0.000*	0.999	0.000*
CHD	-0.263	-0.022	-0.285	-0.233
OLD	-0.405	0.004	-0.401	0.038
NAT	0.149	0.028	0.177	0.300
EDU	0.000*	0.009	0.009	0.098
OOD	0.531	-0.004	0.527	-0.039
GEP	-0.109	0.011	-0.098	0.123

' These are standardized coefficients.
* The parameters are constrained to zero.

supply.

Should the indirect effects of native population and owner-occupied dwellings be attributed solely to hospital beds? Obviously not. Clearly, however, the indirect effects described here are due to the mediating influence of hospital beds and hospital beds only. Although our model cannot speak directly to this issue at this stage, one could argue that the indirect effects, although not substantial, reflect the process of physician distribution. For example, a large proportion of native population in an area creates greater demand for hospital beds, which, in turn, contributes to a larger supply of general(family) practitioners. While it is possible to some extent to encourage general(family) practitioners to set up practice without the benefit of a large supply of hospital beds, government commitment to such programmes should take into account the consequences of a large high-risk population, and, in particular, the aging of the population.

In summary, the consideration of both direct and indirect effects demonstrates the importance of the total effects of demographic and socio-economic factors on distribution of general(family) practitioners. Though the variable hospital beds does not play an important mediating role, it has significant positive effect on the supply of general(family) practitioners in an area. While a similar inference has been drawn by previous investigators (e.g., Marden, 1966), the findings presented here spell out the exact nature of such effects. In essence, the findings suggest that it is not rudimentary to seperate socio-economic or demographic factors from environmental factors, in a causal sense.

6.2.3 Specialists Model at Time 1

The discussion of the model with specialists as the ultimate dependent variable is the purpose of this section. The model contains precisely the same antecedent factors as the other two models. The model is diagrammed in Figure 6.2-3, where the model coefficients are shown. Appendix Table A-9 presents the basic variance-covariance matrix and Table 6.2-7 presents the maximum likelihood estimates computed by LISREL.

The χ^2 for the model is 1.44, with two degrees of freedom and a probability of 0.487. This indicates that the model cannot be rejected statistically. The matrix of residuals, $S-\Sigma$, is shown in Appendix Table A-10. The residuals are small with the largest residual being 0.741, which again suggests that the model fits the data very well. The maximum modification index of 1.30 (Table 6.2-7) indicates that no parameters which were fixed previously

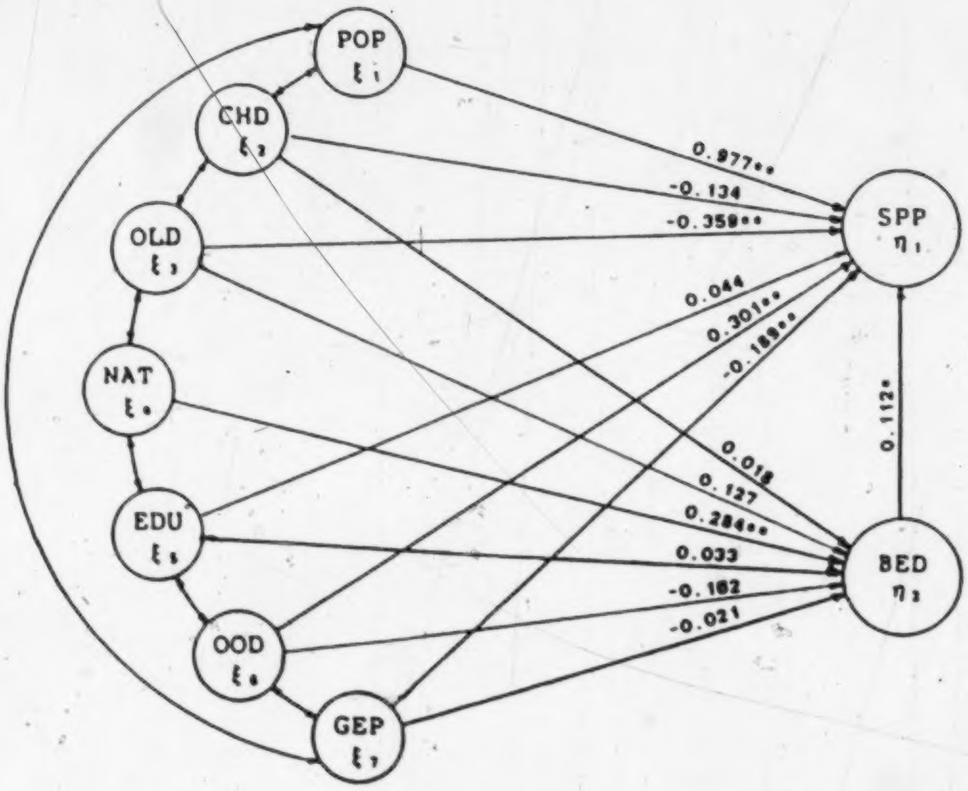

POP ξ_1
CHD ξ_2
OLD ξ_3
NAT ξ_4
EDU ξ_5
OOD ξ_6
GEP ξ_7
SPP η_1
BED η_2
0.977**
-0.134
-0.359**
0.044
0.301**
-0.189**
0.018
0.127
0.284**
0.033
-0.182
-0.021
0.112*

Figure 6.2-3. A Causal Diagram of the Specialists Model at Time 1 with Standardized Parameters as Estimated by LISREL

* Parameter is more than 1.5 times its standard error
** Parameter is more than twice its standard error

Table 6.2-7

Metric and Standarized' Structural Coefficients and Goodness-of-Fit Measures for the Specialists Model at Time 1

	SPP	BED	POP	CHD	OLD	NAT	EDU	OOD	GEP
SPP	0.000* (0.000)	0.252 (0.112)	33.654 (0.977)	-8.159 (-0.134)	-10.384 (-0.359)	0.000* (0.000)	1.458 (0.044)	2.629 (0.301)	-0.106 (-0.189)
BED	0.000* (0.000)	0.000* (0.000)	0.000* (0.000)	0.489 (0.018)	1.632 (0.127)	2.960 (0.284)	0.488 (0.033)	0.630 (-0.162)	-0.005 (-0.021)
R^2	0.784	0.101							
PSI	0.216	0.899							

χ^2=1.44 D. F.=2 P=0.487 GFI=0.998 AGFI=0.961 RMSR=27.126 Max NR=0.741 Max MI=1.30**

R^2 = Squared Multiple Correlations for Structural Equations
PSI = Covariances among the ζ Error Terms
χ^2 = CHI Square
D. F. = Degrees of Freedom
GFI = Goodness-of-Fit Index
AGFI = Adjusted Goodness-of-Fit Index
RMSR = Root Mean Square Residual Correlation
Max NR = Maximum Normalized Residual
Max MI = Maximum Modification Index

' Standardized Coefficients in parantheses
* The parameter is constrained to zero.
** Warrants no further reduction of constraints in the Model is needed.

need to be set free. An examination of the first-order derivatives for the parameters of B previously fixed at zero indicates the possibility of a direct influence of specialists (SPP) upon hospital beds (BED); β_{21} =0.110, which appears to be theoretically plausible.

The proportion of unexplained variance of BED is considerably larger (PSI=0.899). The two predetermined variables, CHD and GEP, have less effects on hospital beds, but these variables have large effects on specialists, as had been anticipated. Therefore the proportion of explained variance is much higher than that for hospital beds (excluding the effect of hospital beds). The amount of explained variance is 0.101 for hospital beds and 0.784 for specialists.

Turning to correlations among antecedent variables (Table 6.2-8), we see that OLD and GEP have moderate relationships (-0.585 and 0.588 respectively) with CHD. Also, there is a moderate negative correlation (-0.488) between POP and OOD and a moderate positive correlation (0.484) between POP and EDU. These are consistent with our earlier findings and need no further explanation. However, it should be mentioned that, with few exceptions, the strength of the relationships are slightly lower than in the case of the earlier models.

Table 6.2-8

PHI Matrix (Covariance Matrix of Exogenous Variables) for the Specialists Model at Time 1

	POP	CHD	OLD	NAT	EDU	OOD	GEP
POP	1.000						
CHD	-0.109	1.000					
OLD	0.079	-0.586	1.000				
NAT	-0.079	0.462	-0.154	1.000			
EDU	0.484	0.021	0.003	0.035	1.000		
OOD	-0.487	0.083	0.405	-0.004	-0.467	1.000	
GEP	0.046	0.588	-0.326	0.398	-0.061	-0.023	1.000

The results shown in Table 6.2-7 indicate that all the exogenous variables with the exception of CHD and EDU have significant direct effects on specialists (SPP); POP is, by far, the strongest predictor of specialist distribution (0.977). This is consistent with our expectations, and offers further support for the conclusions of previous researchers such as Marden (1966). The impact of OLD on specialists is not in the anticipated direction but strong. This suggests that specialists are fewer in areas where the older age-group is over-represented. POP, OOD, and GEP affect specialists in the same direction as hypothesized.

The effect of BED on specialists (SPP) is both significant and in the hypothesized direction; the higher the number of hospital beds, the higher the number of specialists present in the area.

Again, NAT is a significant predictor of BED - note that the algebraic sign has remain consistent across models. As was the case with each of the other models, the number of hospital beds is likely to be larger in areas where a large proportion of the population is native. NAT and GEP have effects in the unexpected direction. Furthermore, the former variable is statistically significant.

Examination of decomposition effects of variables shows that the total effects of OLD is greater and OOD is smaller than their direct effects (Table 6.2-9). To put it differently, BED acts as a mediating factor, although weak, in attracting physicians (specialists) in certain disadvantaged areas. Examination of the indirect influences once again reveals that there are more hospital beds in an area which has a higher proportion of natives and such an area is characterized by a smaller proportion of owner-occupied dwellings.

6.2.4 Combined Model at Time 1

The preceding three sub-sections have discussed the three different models corresponding to the three categories of physicians. A combined model involving general practitioners and family physicians, and specialists is discussed here taking an initial step to consider the interdependencies among physician categories.

In Figure 6.2-4 and Table 6.2-10 the parameter estimates obtained from the variance-covariance matrix in Appendix Table A-9 have been presented. The likelihood ratio χ^2 shown in Table 6.2-10 indicates a satisfactory fit between the model and the data ($\chi^2 = 5.71$, D.F = 5, P = 0.335). Moreover, the sizes of the residuals are all small; the maximum size is 0.749. In the model, the

Table 6.2-9

Decomposition Effects of Endogenous and Exogenous Variables for the Specialists Model at Time 1'

Variables	SPP			BED
	Direct	Indirect	Total	Direct(Total)
SPP	0.000*	0.000*	0.000*	0.000*
BED	0.112	0.000*	0.112	0.000*
POP	0.977	0.000*	0.977	0.000*
CHD	-0.134	0.002	-0.132	0.018
OLD	-0.359	0.014	-0.345	0.127
NAT	0.000*	0.032	0.032	0.284
EDU	0.044	0.003	0.047	0.033
OOD	0.301	-0.018	0.283	-0.162
GEP	-0.189	-0.002	-0.191	-0.021

' These are standardized coefficients.
* The parameters are constrained to zero.

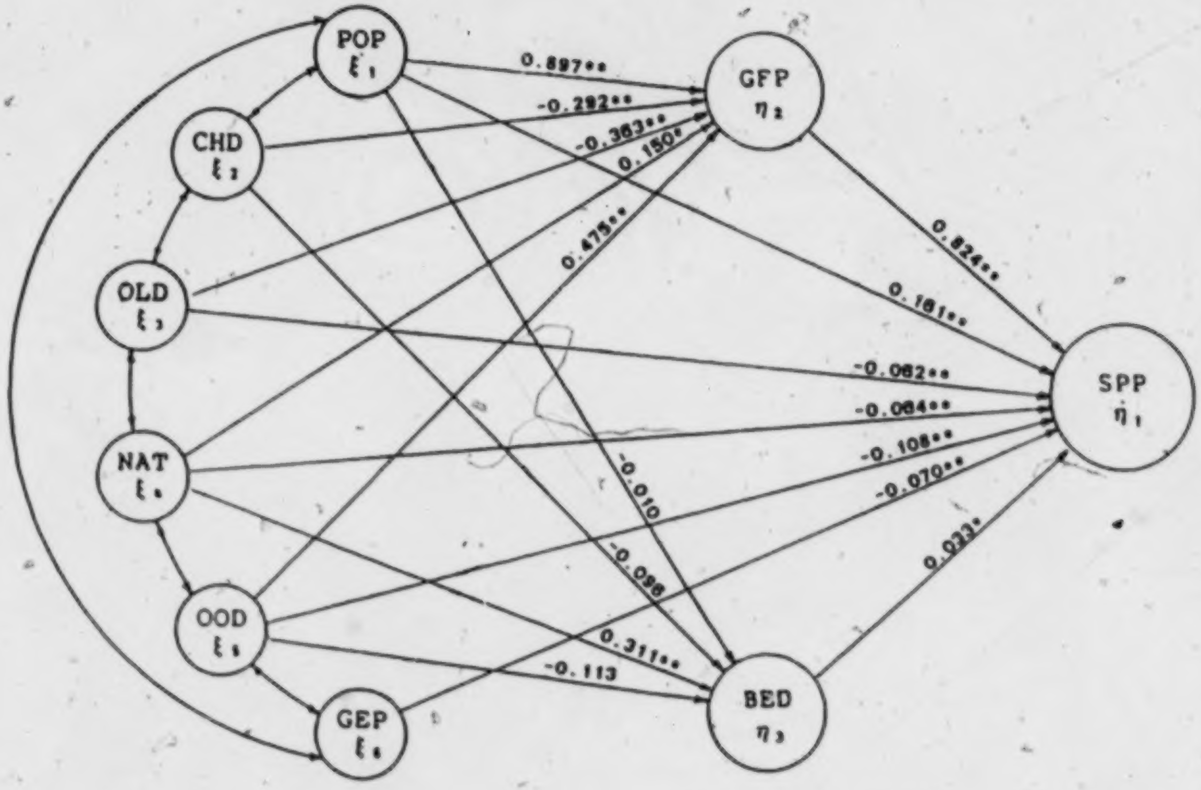

POP
ξ_1
CHD
ξ_2
OLD
ξ_3
NAT
ξ_4
OOD
ξ_5
GEP
ξ_6
GFP
η_2
BED
η_3
SPP
η_1
0.897**
-0.292**
-0.363**
0.150*
0.475**
-0.010
-0.098
0.311**
-0.113
0.824**
0.181**
-0.082**
-0.084**
-0.108**
-0.070**
0.033*

Figure 6.2-4. A Causal Diagram of the Combined Model (Excluding Interns and Residents) at Time 1 with Standardized Parameters as Estimated by LISREL

* Parameter is more than 1.5 times its standard error
** Parameter is more than twice its standard error

Table 6.2-10

Metric and Standarized' Structural Coefficients and Goodness-of-Fit Measures for the Combined Model (Excluding Interns and Residents) at Time 1

	SPP	GFP	BED	POP	CHD	OLD	NAT	OOD	GEP
SPP	0.000*	1.056	0.082	6.169	0.000*	-1.980	-1.655	-1.043	-0.043
	(0.000)	(0.824)	(0.033)	(0.161)	(0.000)	(-0.062)	(-0.064)	(-0.108)	(-0.070)
GFP	0.000*	0.000*	0.000*	26.753	-15.376	-9.090	3.044	3.586	0.000*
	(0.000)	(0.000)	(0.000)	(0.897)	(-0.292)	(-0.363)	(0.150)	(0.475)	(0.000)
BED	0.000*	0.000*	0.000*	-0.149	-2.593	0.000*	3.249	-0.438	0.000*
	(0.000)	(0.000)	(0.000)	(-0.010)	(-0.096)	(0.000)	(0.311)	(-0.113)	(0.000)
R^2	0.943	0.523	0.093						
PSI	0.057	0.477	0.907						

χ^2=5.71 D. F.=5 P=0.335 GFI=0.993 AGFI=0.938 RMSR=142.510Max NR=0.747 Max MI=3.75**

R^2 = Squared Multiple Correlations for Structural Equations
PSI = Covariances among the ζ Error Terms
χ^2 = CHI Square
D. F. = Degrees of Freedom
GFI = Goodness-of-Fit Index
AGFI = Adjusted Goodness-of-Fit Index
RMSR = Root Mean Square Residual Correlation
Max NR = Maximum Normalized Residual
Max MI = Maximum Modification Index

' Standardized Coefficients in parentheses
* The parameter is constrained to zero.
** Warrants no further reduction of constraints in the Model is needed.

parameter β_{32} turned out to have the largest modification index (3.75). Although this value does not suggest a problem of misspecification, it points to the possibility that $\Theta\delta(2,2)$ - the error variance of population under 5 (CHD) - which was fixed, will lead to a reduction in value of the χ^2 by 3.75 if freed. As Appendix Table A-14 shows, four parameters have their first-order derivatives which are non-zero (β_{21}=-0.016; β_{23}=-0.044; β_{31}=-0.065; β_{32}=-0.065; and γ_{26} = 0.202). These are respectively the effects of specialists on general practitioners and family physicians, hospital beds on general practitioners and family physicians, specialists on hospital beds, general practitioners and family physicians on hospital beds, and geographic proximity on general practitioners and family physicians. The omission of the effects was motivated by a desire to keep the models as simple as possible, and on the basis of the expectation that these effects will not be significant. Our findings indicate that even after omitting these effects, the model still fits the data reasonably well.

The results of Table 6.2-10 indicate that the variable specialists (SPP) is very well explained, since only 6% unexplained variance is left. For the intervening variables, general practitioners and family physicians (GFP) and hospital beds (BED), the amount of unexplained variance is relatively large, and the variable BED is not adequately explained by our theory. However, as is clear from our objective, the explanation of this factor was not the purpose of this study in the first place. The explanation of this variable would require the incorporation of different causal variables, perhaps economic, which have been left out.

We may note that POP has a strong effect on general practitioners and family physicians, while the direct effect of POP on specialists (SPP) is very small (0.161). The direct effect of BED on specialists (SPP) is positive and significant but the effect is not as strong as the effect of general practitioners and family physicians. Results indicate considerable support for the direct effect of general practitioners and family physicians (GFP) on specialists (SPP); $\beta_{12}=0.824$. Surprisingly, the direct effect of OOD on specialists (SPP) is negative, opposite to what was observed earlier (Figure 6.2-3).

Table 6.2-11 shows the correlations between the antecedent variables. The coefficients are virtually identical with those found in the earlier models and need no further explanation. In Table 6.2-12, the decomposition effects of the variables is presented. A comparison of the paths from the exogenous variables to the final endogenous variable, specialists is interesting. POP has a larger

Table 6.2-11

PHI Matrix (Covariance Matrix of Exogenous Variables) for the Combined Model (Excluding Interns and Residents) at Time 1

	POP	CHD	OLD	NAT	OOD	GEP
POP	1.000					
CHD	-0.106	1.000				
OLD	0.081	-0.589	1.000			
NAT	-0.083	0.463	-0.149	1.000		
OOD	-0.488	0.082	0.405	-0.005	1.000	
GEP	0.033	0.590	-0.321	0.396	-0.029	1.000

Table 6.2-12

Decomposition Effects of Endogenous and Exogenous Variables for the Combined Model (Excluding Interns and Residents) at Time 1'

	SPP			GFP	BED
Variables	Direct	Indirect	Total	Direct (Total)	Direct (Total)
SPP	0.000*	0.000*	0.000*	0.000*	0.000*
GFP	0.824	0.000*	0.824	0.000*	0.000*
BED	0.033	0.000*	0.033	0.000*	0.000*
POP	0.161	0.739	0.900	0.897	-0.010
CHD	0.000*	-0.244	-0.244	-0.292	-0.096
OLD	-0.062	-0.299	-0.361	-0.363	0.000*
NAT	-0.064	0.134	0.070	0.150	0.311
OOD	-0.108	0.388	0.280	0.475	-0.113
GEP	-0.070	0.000*	-0.070	0.000*	0.000*

' These are standardized coefficients.
* The parameters are constrained to zero.

impact on specialists, through the intervening variables general practitioners and family physicians (GFP), and hospital beds (BED), and, in particular, through GFP than it does directly. Also, OOD and the two age groups (CHD, OLD) have strong indirect effects on specialists. The indirect effects of NAT through its influence on both general practitioners and family physicians (GFP) and hospital beds (BED) are also large. Not at all evident from earlier analyses is the finding that the variable OOD exerts an indirect effect on specialists (SPP) through the intervening variables, which is greater in magnitude but is opposite in sign to the direct effect. That is, OOD as a symbol of economic prosperity could result in an increase in specialists when the causal effect is through general practitioners and family physicians.

In sum, the combined model provides several substantive results:

(a) population size appears to have virtually no direct effect on specialists, although it has substantial positive effects which are mediated by general practitioners and family physicians;

(b) the inverse direct effect of owner-occupied dwellings on specialists is complemented by two countervailing indirect effects of owner-occupied dwellings - one through general practitioners and family physicians, the other through hospital beds; and

(c) native population exerts an indirect effect on specialists through the intervening variables which is more than twice the magnitude of the direct effects.

Further, it should be noted that almost 75% of the indirect impact of POP and OOD, operates via general practitioners and family physicians (GFP): populated areas and areas with a large proportion of owner-occupied dwellings tend to have a large supply of general(family) practitioners, and hence a large supply of specialists. Areas with large proportion of young/old populations are at a greater disadvantage because of fewer general(family) practitioners and specialists.

These results suggest a high level of interdependency among physician groups. The findings of this model imply that supply of general practitioners and family physicians may be crucially important to help us better understand the relationship between demographic and socio-economic factors, and specialists. This finding is important in that specialists form a substantial and growing proportion of the physicians in the country.

6.3 Model-Fitting and Discussion of Results: Models at Time 2

In the four sub-sections to follow, the results of analyses of structural equation models utilizing data for 1981 are presented. The qualities of the models are assessed using different criteria outlined in the previous section. Finally, a brief summary of findings is presented comparing the different models.

6.3.1 Interns and Residents Model at Time 2

The input variance-covariance matrix and factor loadings for the model specified in Figure 6.1-5 are presented in Appendix Table B-1 and B-4 respectively. The estimates for the causal paths among variables are presented in Figure 6.3-1 and Table 6.3-1; the goodness-of-fit measures are presented in Table 6.3-1.

The model yields a test statistic of $\chi^2 = 1.82$ with 2 degrees of freedom and $p = 0.402$, which indicates a perfect fit. The largest residual of 0.933 (γ_{24}) is obtained for the variables BED and NAT. This means that a reduction of the residual association between the variables can possibly be obtained by introducing the effect γ_{24}. This is also suggested by the value of the maximum modification index for γ_{24} (1.75). Although, the introduction of this parameter is theoretically

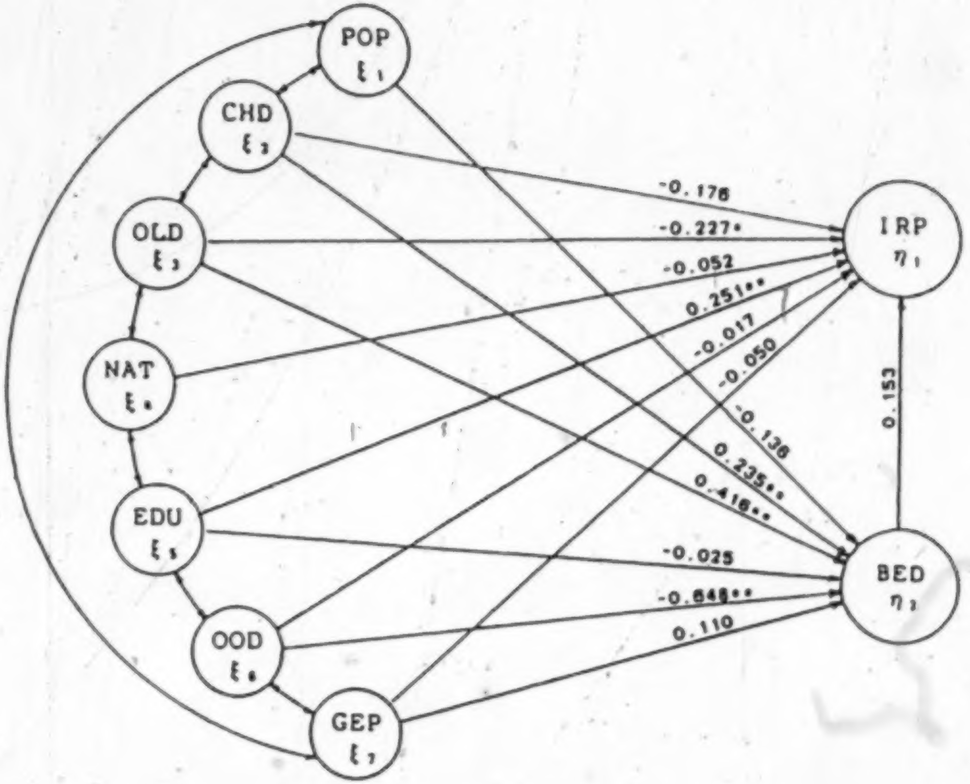

POP
ξ1
CHD
ξ2
OLD
ξ3
NAT
ξ4
EDU
ξ5
OOD
ξ6
GEP
ξ7
IRP
η1
BED
η2
-0.178
-0.227*
-0.052
0.251**
-0.017
-0.050
-0.136
0.235**
0.418**
-0.025
-0.648**
0.110
0.153

Figure 6.3-1. A Causal Diagram of the **Interns and Residents** Model at Time 2 with Standardized Parameters as Estimated by LISREL

* Parameter is more than 1.5 times its standard error
** Parameter is more than twice its standard error

Table 6.3-1

Metric and Standarized' Structural Coefficients and Goodness-of-Fit-Measures for the Interns and Residents Model at Time 2

	IRP	BED	POP	CHD	OLD	NAT	EDU	OOD	GEP
IRP	0.000* (0.000)	0.089 (0.153)	0.000* (0.000)	-5.662 (-0.176)	-2.591 (-0.227)	-0.668 (-0.052)	1.766 (0.251)	-0.058 (-0.017)	-0.012 (-0.050)
BED	0.000* (0.000)	0.000* (0.000)	-2.844 (-0.136)	13.025 (0.235)	8.168 (0.416)	0.000* (0.000)	-0.302 (-0.025)	-3.827 (-0.648)	0.046 (0.110)
R^2	0.177	0.295							
PSI	0.823	0.705							

χ^2=1.82 D. F.=2 P=0.402 GFI=0.998 AGFI=0.946 RMSR=10.328 Max NR=0.933 Max MI=1.75**

R^2 = Squared Multiple Correlations for Structural Equations
PSI = Covariances among the ζ Error Terms
χ^2 = CHI Square
D. F. = Degrees of Freedom
GFI = Goodness-of-Fit Index
AGFI = Adjusted Goodness-of-Fit Index
RMSR = Root Mean Square Residual Correlation
Max NR = Maximum Normalized Residual
Max MI = Maximum Modification Index

' Standardized Coefficients in parentheses
* The parameter is constrained to zero.
** Warrants no further reduction of constraints in the Model is needed.

justifiable, this of course would not provide a considerable improvement in the fit of the model since the variable, BED itself, does not have a major contribution in the overall process. Therefore, it was decided to stick with the original theory that proved to be correct for the largest part.

The model explains only 18% of the variance in interns and residents but 30% in hospital beds. Obviously, these findings suggest that there is room for improvement in the specification of the model by introducing other paths and by adding more efficient variables that have been omitted in the present model.

Table 6.3-2 displays the correlations among the exogenous variables. Three of the correlations - between POP and EDU, POP and OOD, and CHD and OLD - are moderate. Thus, an area with a relatively large proportion of older population has a smaller proportion of children under 5 years, a finding consistent with the earlier models. Also, highly populated areas are characterized by a large proportion of highly educated persons and a lower proportion of owner-occupied dwellings.

Seven of the hypothesized effects are weak based on the lack of statistically significant coefficients shown in Figure 6.3-1 and Table 6.3-1. The major findings are as

Table 6.3-2

PHI Matrix (Covariance Matrix of Exogenous Variables) for the Interns and Residents

Model at Time 2

	POP	CHD	OLD	NAT	EDU	OOD	GEP
POP	1.000						
CHD	-0.312	1.000					
OLD	-0.089	-0.522	1.000				
NAT	-0.074	0.260	-0.123	1.000			
EDU	0.502	-0.202	-0.176	-0.001	1.000		
OOD	-0.505	0.173	0.265	0.087	-0.328	1.000	
GEP	-0.228	0.316	-0.343	0.483	-0.176	0.138	1.000

follows:

1. OOD appears to have no direct effect on interns and residents; nor does CHD. Thus, however, have strong effects on beds. NAT and GEP do not relate to interns and residents and hospital beds;
2. EDU has the largest direct effect on interns and residents (0.251); the higher the level of education in an area the greater the number of interns and residents. A weak negative effect (-0.148) was found between EDU and BED and a weak positive effect (0.110) between GEP and BED. The strong effect (-0.648) of OOD on BED once again confirms the importance of OOD in determining the distribution of hospital beds;
3. the two age groups (CHD and OLD), as noted earlier, have positive effects on hospital beds (BED) indicating the presence of a large number of hospital beds in areas where the young and old age-groups are over-represented; and
4. BED is found to have little effect on interns and residents (0.153). Apparently, the finding of earlier researchers that hospital beds tend to attract greater numbers of physicians does not hold true in this study. One explanation may be that other hospital facilities including modern medical equipment and research facilities may be of greater attraction to

physicians than just the supply of hospital beds.

Perhaps the most important finding here is the confirmation of the mediating role of BED in the determination of distribution of interns and residents (Table 6.3-3). OOD indirectly affects interns and residents more strongly than it does directly. This indicates that areas where there are large proportions of owner-occupied dwellings tend to have smaller numbers of hospital beds and hence smaller numbers of interns and residents. Thus, it may be concluded that it is not enough to improve the hospital facilities alone in order to attract more interns and residents in an area, but, efforts should also be directed to reducing disparities in amenities.

OLD has a positive indirect effect on interns and residents. Because this effect is somewhat strong (-0.064) the total effect on the outcome variable, namely, interns and residents, is also highly affected but maintains a positive influence. In other words, a large proportion of older people in an area produces a greater demand for hospital beds, which, in turn, leads to a large supply of interns and residents. The generalizability of these findings, of course, can only be determined through similar research using other groups of physicians which will be taken up in the following sub-sections.

Table 6.3-3

Decomposition Effects of Endogenous and Exogenous Variables for the Interns and Residents Model at Time 2'

Variables	IRP			BED
	Direct	Indirect	Total	Direct(Total)
IRP	0.000*	0.000*	0.000*	0.000*
BED	0.153	0.000*	0.153	0.000*
POP	0.000*	-0.021	-0.021	-0.136
CHD	-0.176	0.036	-0.140	0.235
OLD	-0.227	0.064	-0.163	0.416
NAT	-0.052	0.000*	-0.052	0.000*
EDU	0.251	-0.004	0.247	-0.025
OOD	-0.017	-0.099	-0.116	-0.648
GEP	-0.050	0.017	-0.033	0.110

' These are standardized coefficients.
* The parameters are constrained to zero.

6.3.2 General (Family) Practitioners Model at Time 2

The estimates of parameters for the postulated model specified in Figure 6.1-6 are shown in Figure 6.3-2. Table 6.3-4 presents a more complete description of the results, including both unstandardized and standardized coefficients and the goodness-of-fit measures. Table 6.3-5 presents the correlations between the exogenous variables in the model. Appendix Table B-5 presents the input variance-covariance matrix and B-8 presents the factor loadings and the error terms for variables in the model.

The model yields a likelihood ratio test statistic of $\chi^2 = 0.48$ with two degrees of freedom and $p = 0.787$. Thus the model fits the data very well. This is also reflected in the value of the maximum normalized residual which is 0.466. Furthermore, the maximum modification index of 0.46 suggests that no further improvement in the fit of the model is necessary. The first-order derivatives for the parameters are all zero (see Appendix Table B-7) which again suggests that no correction is needed for the model under specification.

The model accounts for 20% of the variance in general practitioners and family physicians and approximately 28% of the variance in hospital beds. Given the relatively poor influence of hospital beds on general(family)

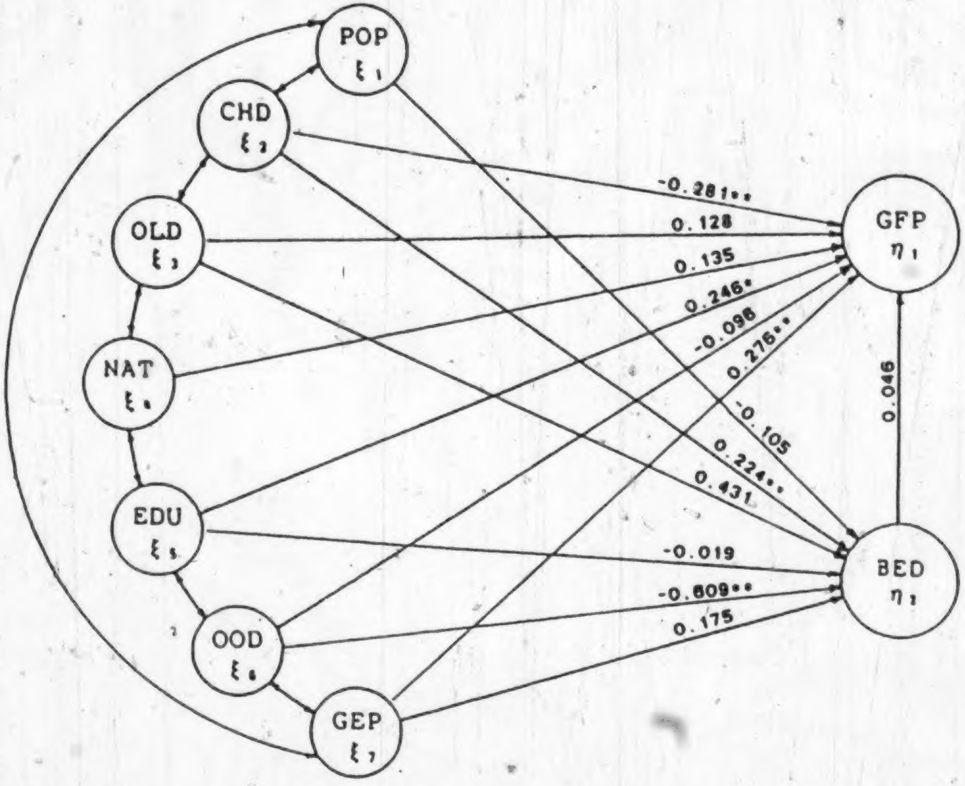

POP
ξ_1
CHD
ξ_2
OLD
ξ_3
NAT
ξ_4
EDU
ξ_5
OOD
ξ_6
GEP
ξ_7
GFP
η_1
BED
η_2
-0.281**
0.128
0.135
0.246*
-0.098
0.276**
-0.105
0.224**
0.431
-0.019
-0.609**
0.175
0.046

Figure 6.3-2 The Causal Diagram of the General (Family) Practitioners Model at Time 2 with Standardized Parameters as Estimated by LISREL

* Parameter is more than 1.5 times its standard error
** Parameter is more than twice its standard error

Table 6.3-4

Metric and Standarized' Structural Coefficients and Goodness-of-Fit Measures for the General (Family) Practitioners Model at Time 2

	GFP	BED	POP	CHD	OLD	NAT	EDU	OOD	GEP
GFP	0.000* (0.000)	0.021 (0.046)	0.000* (0.000)	-6.175 (-0.281)	1.008 (0.128)	0.605 (0.135)	1.425 (0.246)	-0.247 (-0.096)	0.051 (0.276)
BED	0.000* (0.000)	0.000* (0.000)	-2.371 (-0.105)	10.701 (0.224)	7.422 (0.431)	0.000* (0.000)	-0.235 (-0.019)	-3.417 (-0.609)	0.070 (0.175)
R^2	0.204	0.275							
PSI	0.796	0.725							

χ^2=0.48 D. F.=2 P=0.787 GFI=1.000 AGFI=0.989 RMSR= 3.745 Max NR=0.466 Max MI=0.46**

R^2 = Squared Multiple Correlations for Structural Equations
PSI = Covariances among the ζ Error Terms
χ^2 = CHI Square
D. F. = Degrees of Freedom
GFI = Goodness-of-Fit Index
AGFI = Adjusted Goodness-of-Fit Index
RMSR = Root Mean Square Residual Correlation
Max NR = Maximum Normalized Residual
Max MI = Maximum Modification Index

' Standardized Coefficients in parentheses
* The parameter is constrained to zero.
** Warrants no further reduction of constraints in the Model is needed.

Table 6.3-5

PHI Matrix (Covariance Matrix of Exogenous Variables) for the General (Family) Practitioners Model at Time 2

	POP	CHD	OLD	NAT	EDU	OOD	GEP
POP	1.000						
CHD	-0.233	1.000					
OLD	-0.123	-0.524	1.000				
NAT	-0.080	0.409	-0.071	1.000			
EDU	0.499	-0.139	-0.206	-0.050	1.000		
OOD	-0.510	0.063	0.314	0.011	-0.379	1.000	
GEP	-0.228	0.388	-0.300	0.401	-0.168	0.183	1.000

practitioners, the model suggests that further research should focus on mediating factors other than hospital beds.

Relative to other determinants, CHD appears to have the greatest direct impact on general practitioners and family physicians (-0.281); the higher the proportion of population under 5, the fewer the general practitioners and family physicians. Other exogenous variables in order of variable strength are GEP (0.276); EDU (0.246); and NAT (0.135). Hospital beds (BED), on the other hand, have virtually no effect on general(family) practitioners (the coefficients is 0.046).

All of the variables with the exception of POP and EDU have significant impact on BED; the largest influence is by owner-occupied dwellings (-0.609). As noted earlier, this may mean that areas having a large proportion of owner occupied dwellings tend to have fewer hospital beds.

The decomposition effects of variables are presented in Table 6.3-6. The indirect effects of variables via hospital beds are minimal. This suggests that the inclusion of hospital beds in the model as an endogenous variable adds less than the other exogenous variables to our understanding of the overall causal process.

Table 6.3-6

Decomposition Effects of Endogenous and Exogenous Variables for the General (Family) Practitioners Model at Time 2'

Variables	GFP			BED
	Direct	Indirect	Total	Direct(Total)
GFP	0.000*	0.000*	0.000*	0.000*
BED	0.046	0.000*	0.046	0.000*
POP	0.000*	-0.005	-0.005	-0.105
CHD	-0.281	0.010	-0.271	0.224
OLD	0.128	0.019	0.147	0.431
NAT	0.135	0.000*	0.135	0.000*
EDU	0.246	-0.001	0.245	-0.019
OOD	-0.096	-0.028	-0.124	-0.609
GEP	0.276	0.008	0.284	0.175

' These are standardized coefficients.
* The parameters are constrained to zero.

6.3.3 Specialists Model at Time 2

Figure 6.3-3 presents parameter estimates (standardized) for the specialists model at Time 2. Table 6.3-7 presents the standardized and unstandardized parameter estimates and the goodness-of-fit measures. The correlations among the exogenous variables is presented in Table 6.3-8. The input variance-covariance matrix is presented in Appendix Table B-9 and the measurement model parameters are given in Appendix Table B-12.

The goodness-of-fit test yields a $\chi^2 = 1.22$, degrees of freedom = 2, and $p = 0.543$, which represents an acceptable fit. Inspection of the residuals in Appendix Table B-10 reveals that the highest value (0.628) occurs between NAT and BED, which is insignificant. Further, the maximum modification index is very low (0.92), suggesting that the model is well specified. Finally, the first-order derivatives are all zero. These indicate that the entire pattern of covariances conforms perfectly to the hypothesized structures and thus provides support for the overall theory.

The model of Figure 6.3-3 explains approximately 76% of the variance in specialists and 24% of the variance in hospital beds.

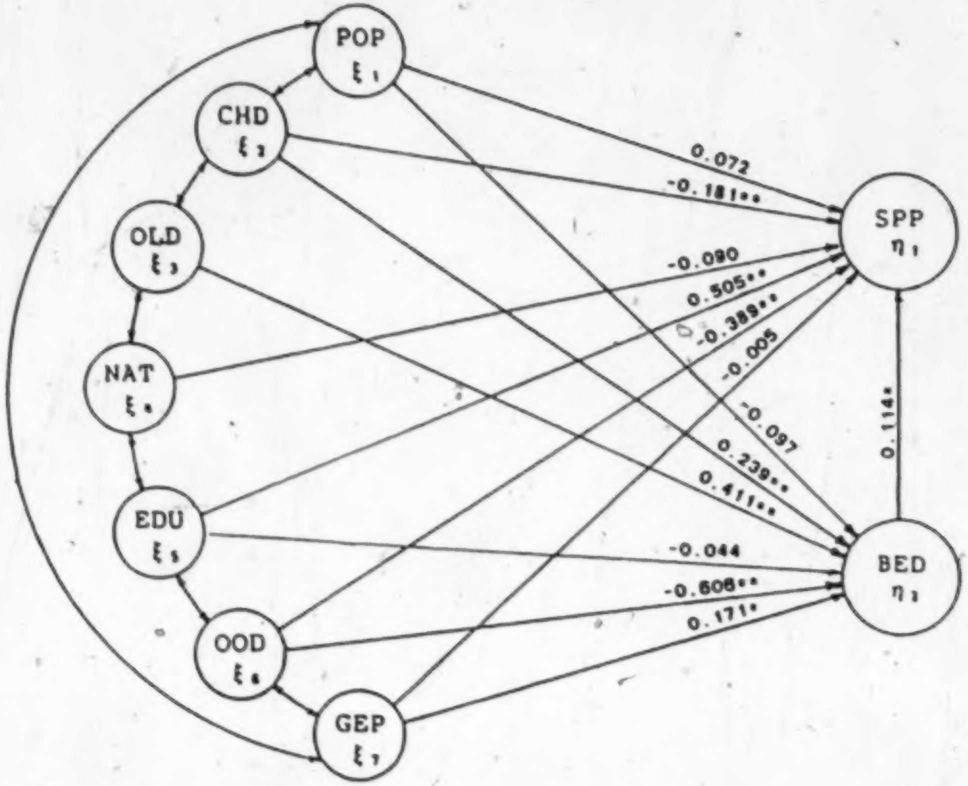

POP ξ_1
CHD ξ_2
OLD ξ_3
NAT ξ_4
EDU ξ_5
OOD ξ_6
GEP ξ_7
SPP η_1
BED η_2
0.072
-0.181**
-0.090
0.505**
-0.389**
-0.005
-0.097
0.239**
0.411**
-0.044
-0.608**
0.171*
0.114*

Figure 6.3-3. A Causal Diagram of the Specialists Model at Time 2 with Standardized Parameters as Estimated by LISREL

* Parameter is more than 1.5 times its standard error
** Parameter is more than twice its standard error

Table 6.3-7

Metric and Standardized' Structural Coefficients and Goodness-of-Fit Measures for the Specialists Model at Time 2

	SPP	BED	POP	CHD	OLD	NAT	EDU	OOD	GEP
SPP	0.000* (0.000)	0.072 (0.114)	0.982 (0.072)	-5.743 (-0.181)	0.000* (0.000)	-0.558 (-0.090)	3.986 (0.505)	-1.412 (-0.389)	-0.001 (-0.005)
BED	0.000* (0.000)	0.000* (0.000)	-2.099 (-0.097)	12.061 (0.239)	7.649 (0.411)	0.000* (0.000)	-0.553 (-0.044)	-3.502 (-0.606)	0.068 (0.171)
R^2	0.762	0.263							
PSI	0.238	0.737							

χ^2=1.22 D. F.=2 P=0.543 GFI=0.999 AGFI=0.968 RMSR= 6.762 Max NR=0.628 Max MI=0.92**

R^2 = Squared Multiple Correlations for Structural Equations
PSI = Covariances among the ζ Error Terms
χ^2 = CHI Square
D. F. = Degrees of Freedom
GFI = Goodness-of-Fit Index
AGFI = Adjusted Goodness-of-Fit Index
RMSR = Root Mean Square Residual Correlation
Max NR = Maximum Normalized Residual
Max MI = Maximum Modification Index

' Standardized Coefficients in parentheses
* The parameter is constrained to zero.
** Warrants no further reduction of constraints in the Model is needed.

Table 6.3-8

PHI Matrix (Covariance Matrix of Exogenous Variables) for the Specialists Model at Time 2

	POP	CHD	OLD	NAT	EDU	OOD	GEP
POP	1.000						
CHD	-0.271	1.000					
OLD	-0.101	-0.590	1.000				
NAT	-0.073	0.463	-0.164	1.000			
EDU	0.490	-0.178	-0.175	-0.034	1.000		
OOD	-0.500	0.127	0.270	-0.008	-0.326	1.000	
GEP	-0.228	0.433	-0.377	0.454	-0.165	0.168	1.000

The parameter estimates shown in Figure 6.3-3 and Table 6.3-7 indicate that the structural relationships hypothesized in the figure are well supported, with few exceptions. Both EDU and OOD are strongly related to specialists (SPP). Note that EDU plays a greater role in variation in specialists than OOD, although both have significant impacts. NAT has a negative and statistically insignificant influence on specialists. Although small, BED is shown to have a significant effect on specialists (SPP).

Contrary to predictions, none of the exogenous variables, perhaps with the exceptions of OLD and OOD, affect specialists through BED; the direct and total effects of variables are almost equal in magnitude (Table 6.3-9). OOD, as noted earlier, has the strongest indirect effect (-0.068) on specialists.

Results in Table 6.3-9 can be interpreted as providing some evidence, albeit weak, to support our earlier argument - hospital beds do appear to play a less significant role in attracting the number of specialists. It is interesting to note that, after adjusting for the effects of hospital beds on specialists, age-composition and socio-economic characteristics of areas contribute significantly to variation in specialists. This implies that the importance of environmental/technological factors

Table 6.3-9

Decomposition Effects of Endogenous and Exogenous Variables for the Specialists Model at Time 2'

Variables	SPP			BED
	Direct	Indirect	Total	Direct(Total)
SPP	0.000*	0.000*	0.000*	0.000*
BED	0.114	0.000*	0.114	0.000*
POP	0.072	-0.011	0.061	-0.097
CHD	-0.181	0.027	-0.154	0.239
OLD	0.000*	0.047	0.047	0.411
NAT	-0.090	0.000*	-0.090	0.000*
EDU	0.505	-0.005	0.500	-0.044
OOD	-0.389	-0.068	-0.457	-0.606
GEP	-0.005	0.019	0.014	0.171

' These are standardized coefficients.
* The parameters are constrained to zero.

(e.g., hospital beds) relative to other characteristics of the area may be somewhat overstated in earlier studies.

6.3.4 Combined Models at Time 2

In this section, models incorporating different categories of physicians are estimated using data for 1981. The section begins with a combined model of all the three categories of physicians and then employs LISREL to move towards a more restricted model to include only general practitioners and family physicians, and specialists in paths that are statistically significant. Each model is tested for its goodness-of-fit to a set of observed covariances among the constructs.

A single variance-covariance matrix was computed for both models and is presented in Appendix Table B-13. Each of the analyses used a subset of these observed covariances.

Figure 6.3-4 and Table 6.3-10 present the parameter estimates of the combined model involving the three categories of physicians as endogenous variables. Results indicate considerable support for the reciprocal effects hypothesized by the theoretical specification. The model fits the data well with a chi square of 6.37 at 7 degrees of freedom for a probability of 0.498. For the model, the maximum value of the normalized residual is 0.568 and the

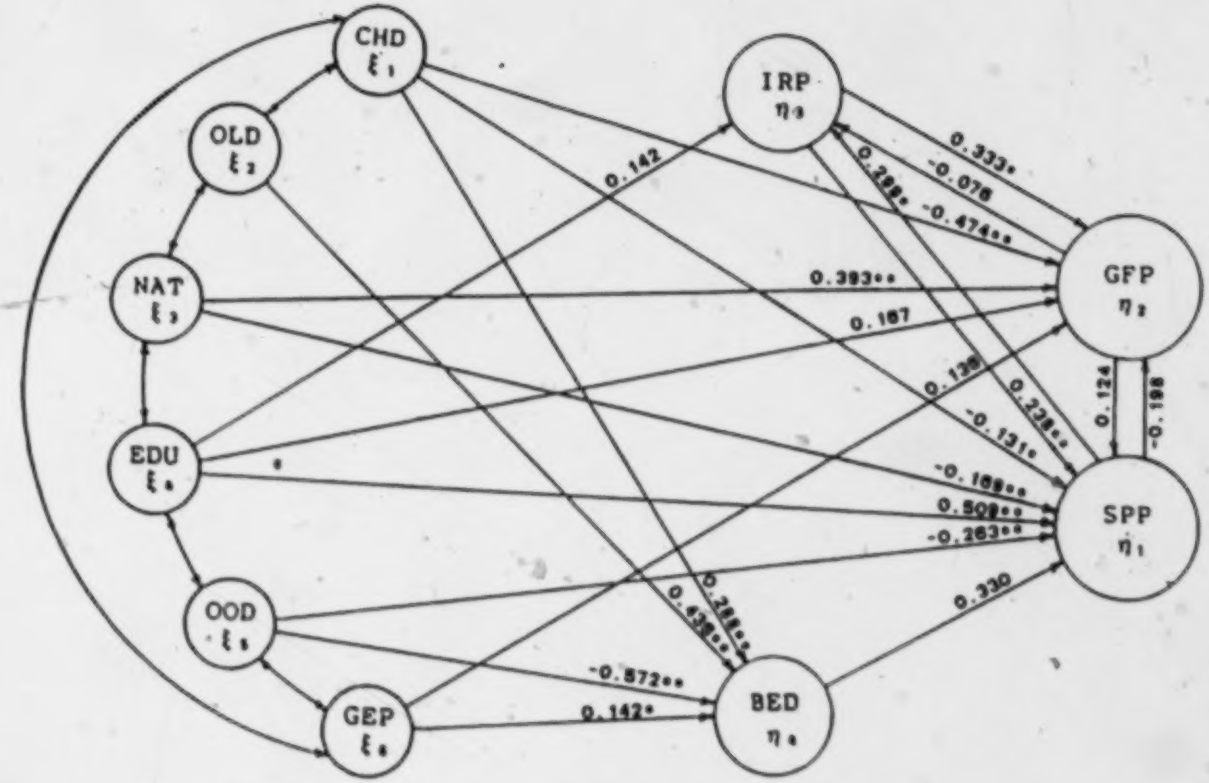

CHD ξ_1
OLD ξ_2
NAT ξ_3
EDU ξ_4
OOD ξ_5
GEP ξ_6
IRP η_3
GFP η_2
SPP η_1
BED η_4
0.142
0.333*
-0.078
0.298*
-0.474**
0.393**
0.187
0.138
0.238**
-0.131*
0.124
-0.198
-0.168**
0.509**
-0.263**
0.288**
0.438**
0.330
-0.572**
0.142*

Figure 6.3-4. A Causal Diagram of the Combined Model at Time 2 with Standardized Parameters as Estimated by LISREL

* Parameter is more than 1.5 times its standard error
** Parameter is more than twice its standard error

Table 6.3-10

Metric and Standarized[1] Structural Coefficients and Goodness-of-Fit Measures for the Combined Model (Including Interns and Residents) at Time 2

	SPP	GFP	IRP	BED	CHD	OLD	NAT	EDU	OOD	GEP
SPP	0.000* (0.000)	0.166 (0.124)	0.259 (0.238)	0.210 (0.330)	-4.783 (-0.131)	0.000* (0.000)	-2.391 (-0.169)	3.973 (0.509)	-1.008 (-0.263)	0.000* (0.000)
GFP	-0.148 (-0.198)	0.000* (0.000)	0.272 (0.333)	0.000* (0.000)	-12.953 (-0.474)	0.000* (0.000)	4.174 (0.393)	0.975 (0.167)	0.000* (0.000)	0.027 (0.136)
IRP	0.275 (0.299)	-0.093 (-0.076)	0.000* (0.000)	0.000* (0.000)	0.000* (0.000)	0.000* (0.000)	0.000* (0.000)	1.019 (0.142)	0.000* (0.000)	0.000* (0.000)
BED	0.000* (0.000)	0.000* (0.000)	0.000* (0.000)	0.000* (0.000)	16.444 (0.288)	8.955 (0.436)	0.000* (0.000)	0.000* (0.000)	-3.439 (-0.572)	0.059 (0.142)
R^2	0.828	0.342	0.272	0.267						

χ^2=6.37 D. F.=7 P=0.498 GFI=0.992 AGFI=0.938 RMSR=20.286 Max NR=0.568 Max MI=2.47**

R^2 = Squared Multiple Correlations for Structural Equations
χ^2 = CHI Square
D. F. = Degrees of Freedom
GFI = Goodness-of-Fit Index
AGFI = Adjusted Goodness-of-Fit Index
RMSR = Root Mean Square Residual Correlation
Max NR = Maximum Normalized Residual
Max MI = Maximum Modification Index

[1] Standardized Coefficients in parentheses
* The parameter is constrained to zero.
** Warrants no further reduction of constraints in the Model is needed.

modification index is 2.47. These findings further provide a basis for accepting the model. Several of the parameter estimates are statistically significant and associated standard errors are small.

The model explains approximately 83% variance in specialists, 34% variance in general practitioners and family physicians, 27% variance in interns and residents, and 27% variance in hospital beds.

The correlations between the exogenous variables are presented in Table 6.3-11. CHD is moderately (-0.508) correlated with OLD. Not surprisingly, NAT is positively and moderately (0.487) correlated with GEP. This means that remote areas are characterized by large proportions of native population. Not surprisingly NAT is nearly independent of EDU and OOD.

Finally, the lower panel of Table 6.3-11 contains the PSI's, the standardized variances of the residuals (diagonal elements) and the correlations between residuals (off diagonal elements). As can be seen, the correlations between residuals are insignificant (the highest value is -0.225). Thus we are justified in concluding that there exists fewer or no unmeasured exogenous variable(s) that significantly affect(s) both the hospital beds and the physician variables.

Table 6.3-11

PHI Matrix (Covariance Matrix of Exogenous Variables) for the Combined Model (Including Interns and Residents) at Time 2

	CHD	OLD	NAT	EDU	OOD	GEP
CHD	1.000					
OLD	-0.508	1.000				
NAT	0.280	-0.148	1.000			
EDU	-0.217	-0.171	0.006	1.000		
OOD	0.199	0.236	0.084	-0.293	1.000	
GEP	0.313	-0.353	0.487	-0.184	0.149	1.000

PSI Matrix (Variance-Covariance Matrix of Structural Errors) for the Combined Model (Including Interns and Residents) at Time 2

	SPP	GFP	IRP	BED
SPP	0.172			
GFP	0.000	0.658		
IRP	0.000	0.000	0.728	
BED	-0.225	0.087	0.093	0.733

To sum up the results based on direct effects of variables (Figure 6.3-4),the following relations are found:

1. CHD negatively affects both general practitioners and family physicians (GFP) and specialists (SPP) and positively affects BED;
2. OLD is positively related to BED. Large proportions of both young and old populations are linked to large hospital bed ratios;
3. NAT is positively related to general practitioners and family physicians (GFP) and negatively related to specialists (SPP). That is, areas large in native population, are larger in general practitioners and family physicians, and smaller in specialists;
4. the paths showing the effects of EDU on physician categories are in the direction predicted (i.e. positive), although the variable has stronger effect on specialists;
5. OOD relates negatively to both specialists (SPP) and BED. Thus, both specialists and hospital beds are fewer where owner occupied dwellings are in large proportions;
6. There is a small positive effect of GEP on general practitioners and family physicians (GFP) and a significant positive effect on BED;
7. While the effect of general practitioners and family

physicians on specialists is positive, the effect of specialists on general practitioners and family physicians is negative. Similarly, the effect of interns and residents on general practitioners and family physicians is positive whereas the effect of general practitioners and family physicians on interns and residents is negative. The reciprocal effects between interns and residents and specialists are both positive and statistically significant; and

8. Although not significant, BED afffects specialists (SPP) in the positive direction.

The model contains several paths that are statistically insignificant. These paths are dropped to form a modified structural equation model which will be discussed later in this section.

Examination of total effects shows that most variables assume somewhat greater importance than was implied by consideration of their direct effects alone (Tables 6.3-12, 6.3-13, and 6.3-14). The indirect effects of variables on specialists suggest two relationships of substantive significance: an area's general(family) practitioner supply positively affects specialist supply regardless of whether or not the area contains a large proportion of native population. Also, residential areas tend to have fewer hospital beds and hence fewer

Table 6.3-12

Decomposition Effects of Endogenous and Exogenous Variables on Specialists for the Combined Model (Including Interns and Residents at Time 2[1]

Variables	Direct	SPP Indirect (via)				Total
		GFP	IRP	BED	Total[2]	
GFP	0.124	0.000*	-0.018	0.000*	-0.018	0.106
IRP	0.238	0.041	0.000*	0.000*	0.041	0.279
BED	0.330	0.000*	0.000*	0.000*	0.000*	0.330
CHD	-0.131	-0.059	0.000*	0.095	0.036	-0.095
OLD	0.000*	0.000*	0.000*	0.153	0.153	0.153
NAT	-0.169	0.032	0.000*	0.000*	0.032	-0.137
EDU	0.509	0.027	0.037	0.000*	0.093	0.602
OOD	-0.263	0.000*	0.000*	-0.189	-0.218	-0.481
GEP	0.000*	0.017	0.000*	0.047	0.065	0.065

* The parameters are constrained to zero.

[1] These are standardized coefficients.

[2] Includes effects through GFP and IRP, GFP and BED, and IRP and BED.

Table 6.3-13

Decomposition Effects of Endogenous and Exogenous Variables on General Practitioners and Family Physicians for the Combined Model (Including Interns and Residents) at Time 2[1]

Variables	Direct	GFP Indirect (via)		Total[2]	Total
		SPP	IRP		
SPP	-0.198	0.000*	0.100	0.100	-0.098
IRP	0.333	-0.047	0.000*	-0.047	0.286
BED	0.000*	-0.065	0.000*	-0.065	-0.065
CHD	-0.474	-0.026	0.000*	0.020	-0.454
OLD	0.000*	0.000*	0.000*	-0.015	-0.015
NAT	0.393	-0.033	0.000*	0.033	0.397
EDU	0.167	-0.101	0.047	-0.016	0.151
OOD	0.000*	-0.052	0.000*	0.046	0.046
GEP	0.136	0.000*	0.000*	-0.010	0.126

---

[1] These are standardized coefficients.

[2] Includes efects through SPP and IRP; SPP and BED.

* The parameters are constrained to zero.

Table 6.3-14

Decomposition Effects of Endogenous and Exogenous Variables on Interns and Residents and Hospital Beds for the Combined Model at Time 2[1]

	IRP					BED
Variables	Direct	Indirect (via)			Total	Direct
		SPP	GFP	Total[2]		(Total)
SPP	0.299	0.000*	-0.066	-0.066	0.233	0.000*
GFP	-0.076	0.037	0.000*	0.037	-0.039	0.000*
BED	0.000*	0.099	0.000*	0.077	0.077	0.000*
CHD	0.000*	-0.039	0.036	0.007	0.007	0.288
OLD	0.000*	0.000*	0.000*	0.047	0.047	0.436
NAT	0.000*	-0.051	0.131	-0.071	-0.071	0.000*
EDU	0.142	0.152	0.056	0.103	0.311	0.000*
OOD	0.000*	-0.079	0.000*	-0.147	-0.147	-0.572
GEP	0.000*	0.000*	0.045	0.010	0.010	0.142

* The parameters are constrained to zero.

[1] These are standardized coefficients.

[2] Include effects through GFP and SPP, SPP and BED.

specialists. Examination of the indirect effects of variables on general(family) practitioners suggest that hospital bed supply facilitates the supply of specialists, which, in turn, leads to a small supply of general(family) practitioners. Also, areas high in proportions of owner occupied dwellings have not been the recipients of larger supplies of hospital beds and specialists, but they are the recipients of larger supply of general practitioners and family physicians.

Finally, the indirect effects of variables on interns and residents presented in Table 6.3-14 reveal the following significant findings: specialists are more likely to be found in areas which have smaller proportion of owner-occupied dwellings and a larger proportion of highly educated persons. One may observe that roughly half of the indirect effect of owner-occupied dwellings and two-thirds of the indirect effect of education operates via specialists. Areas with a high proportion of owner occupied dwellings recorded low physician-population ratios.

The observed negative relationship is not surprising for two reasons. First, whatever be the reasons, a large number of owner occupied dwellings in an area, in effect reduces hospitalization rates and thereby lowers physician ratios. This observation conforms to earlier studies on the ecological correlates of psychiatric illness which showed compressed neighbourhood conditions as defined by number of families per census tract had lower hospital admission rates (Pablo and McDougall, 1985). Second, human ecologists would stress the theory of ecological expansion and argue that with the centralization of specialized functions and services in the inner core, the outer area takes on increasingly the character of residential centres (Schnore, 1956; Berry and Cohen, 1973; Palen, 1981). For instance, our analysis has suggested that the decentralization of residential centres lags behind that of institutionalized services such as medical services.

A cursory look at the total effects presented in Tables 6.3-12, 6.3-13 and 6.3-14 indicates that the relative effects of the variables vary considerably among physician categories. A higher proportion of highly educated persons is, by far, the most important contributor to interns and residents. The total effects of this variable is 0.311. By contrast, a low proportion of population under 5 years and a higher proportion of native population contribute significantly to general practitioners and family physicians (the total effects are -0.454 and 0.397 respectively). Education and owner-occupied dwellings which are fairly strongly linked to specialists (0.602 and -0.481) are only slightly related to general practitioners and family physicians

(0.151 and 0.046). The impact of the latter variable is particularly interesting because it suggests that areas high in owner-occupied dwellings tend to have relatively large number of general practitioners and family physicians and considerably smaller number of specialists due mainly to the mediating role of available hospital facilities (e.g., hospital beds).

Our next step is to estimate the model in Figure 6.3-5 where interns and residents are eliminated.

Table 6.3-15 contains the parameter estimates of this model (unstandardized and standardized). The χ^2 with 4 degrees of freedom is 3.10 for a P=0.541, indicating a good fit. Other standard indicators also suggest that the model fits the data well (Max NR=0.611 and Max MI=2.47).

The model accounts for 78% of the variance in specialists, 29% of the variance in general(family) practitioners, and 26% of the variance in hospital beds. Thus the variables in the models are more successful at predicting specialists (of course, in the presence of other physician groups) than at predicting general(family) practitioners or hospital beds. Although predictive ability of the present model differs from that of the model just discussed, the effects of variables do not differ in many respects. The major result to note from Table 6.3-15 of the effects of variables is that CHD fails

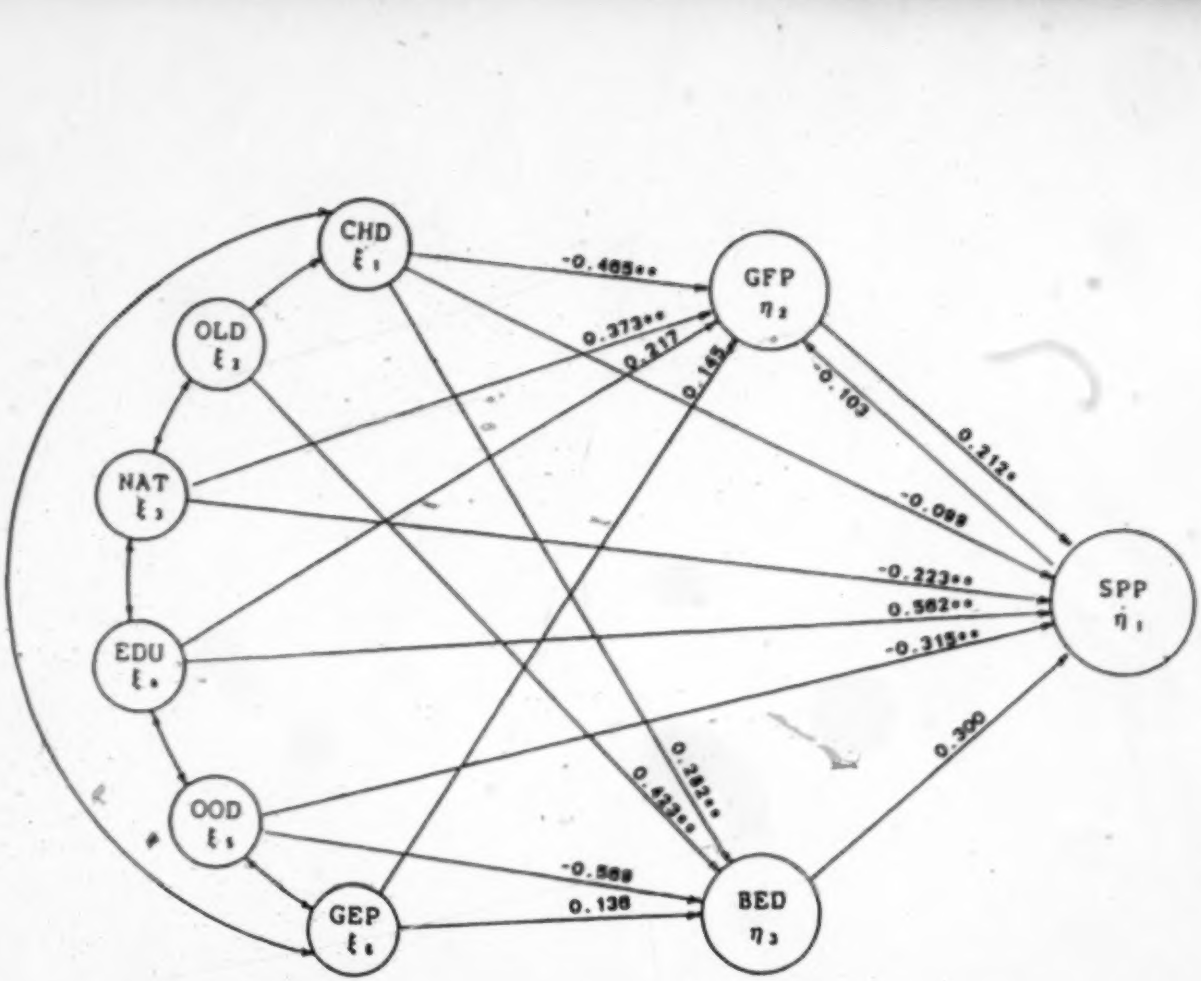

CHD
ξ_1
OLD
ξ_2
NAT
ξ_3
EDU
ξ_4
OOD
ξ_5
GEP
ξ_6
GFP
η_2
BED
η_3
SPP
η_1
-0.465**
0.373**
0.217
0.145
-0.103
0.212*
-0.098
-0.223**
0.562**
-0.315**
0.300
0.282**
0.423**
-0.568
0.136

Figure 6.3-5. A Causal Diagram of the Combined Model (Excluding Interns and Residents) at Time 2 with Standardized Parameters as Estimated by LISREL

* Parameter is more than 1.5 times its standard error
** Parameter is more than twice its standard error

Table 6.3-15

Metric and Standarized[1] Structural Coefficients and Goodness-of-Fit-Measures for the Combined Model (Excluding Interns and Residents) at Time 2

	SPP	GFP	BED	CHD	OLD	NAT	EDU	OOD	GEP
SPP	0.000* (0.000)	0.283 (0.212)	0.192 (0.300)	-3.603 (-0.099)	0.000* (0.000)	-3.155 (-0.223)	4.385 (0.562)	-1.207 (-0.315)	0.000* (0.000)
GFP	-0.077 (-0.103)	0.000* (0.000)	0.000* (0.000)	-12.717 (-0.465)	0.000* (0.000)	3.961 (0.373)	1.272 (0.217)	0.000* (0.000)	0.029 (0.145)
BED	0.000* (0.000)	0.000* (0.000)	0.000* (0.000)	16.094 (0.282)	8.683 (0.423)	0.000* (0.000)	0.000* (0.000)	-3.414 (-0.569)	0.056 (0.136)
R^2	0.776	0.294	0.262						

χ^2=3.10 D. F.=4 P=0.541 GFI=0.996 AGFI=0.952 RMSR=12.372 Max NR=0.611 Max MI=2.47**

R^2 = Squared Multiple Correlations for Structural Equations
χ^2 = CHI Square
D. F. = Degrees of Freedom
GFI = Goodness-of-Fit Index
AGFI = Adjusted Goodness-of-Fit Index
RMSR = Root Mean Square Residual Correlation
Max NR = Maximum Normalized Residual
Max MI = Maximum Modification Index

[1] Standardized Coefficients in parentheses
* The parameter is constrained to zero.
** Warrants no further reduction of constraints in the Model is needed.

Table 6.3-16

PHI Matrix (Covariance Matrix of Exogenous Variables) for the Combined Model (Excluding Interns and Residents) at Time 2

	CHD	OLD	NAT	EDU	OOD	GEP
CHD	1.000					
OLD	-0.507	1.000				
NAT	0.279	-0.150	1.000			
EDU	-0.217	-0.168	0.007	1.000		
OOD	0.200	0.236	0.084	-0.292	1.000	
GEP	0.314	-0.354	0.487	-0.186	0.149	1.000

PSI Matrix (Variance-Covariance Matrix of Structural Errors) for the Combined Model (Excluding Interns and Residents) at Time 2.

	SPP	GFP	BED
SPP	0.224		
GFP	0.000	0.706	
BED	-0.190	0.117	0.738

Table 6.3-17

Decomposition Effects of Endogenous an Exogenous Variables for the Combined Model (Excluding Interns and Residents) at Time 2[1]

Variables	SPP				GFP			BED
	Direct	Indirect (via) GFP	BED	Total[2]	Direct	Indirect via SPP	Total[3]	Direct (Total)
SPP	0.000*	0.000*	0.000	0.000*	-0.103	0.000*	-0.103	0.000*
GFP	0.212	0.000*	0.000	0.212	0.000*	0.000	-0.103	0.000*
BED	0.300	0.000*	0.000	0.300	0.000*	-0.031	-0.031	0.000*
CHD	-0.099	-0.099	0.085	-0.111	-0.465	0.010	-0.454	0.282
OLD	0.000*	0.000	0.124	0.124	0.000*	0.000	-0.013	0.423
NAT	-0.223	0.079	0.000	-0.141	0.373	0.023	0.388	0.000*
EDU	0.562	0.046	0.000	0.595	0.217	-0.058	0.156	0.000*
OOD	-0.315	0.000	-0.171	-0.475	0.000*	0.032	0.049	-0.569
GEP	0.000*	0.031	0.041	0.070	0.145	0.000	0.138	0.136

[1] These are standardized coefficients.
[2] Includes effects through GFP and BED.
[3] Includes effects through SPP and BED.
* The parameters are constrained to zero.

to have a significant direct effect on specialists. Also, results here offer a stronger support for a reciprocal model of physician distribution. Consistent with our model specification, general(family) practitioner supply has significant immediate consequences for specialist supply and vice versa.

Following other researchers, we find further support for the importance of distinguishing among the different types of physicians. One might observe that while education (0.562) and owner-occupied dwellings (-0.315) have the strongest direct effects on specialists, population under 5 years (-0.454) and native population (0.388) have the strongest direct effects on general practitioners and family physicians. These variables also have the highest indirect effects.

CHAPTER 7

MODELLING AND ESTIMATING CHANGE IN PHYSICIAN DISTRIBUTION

This chapter is concerned with the analysis of change in physician distribution over two time points, 1971 and 1981. The importance of understanding the relationship between changes in demographic, socio-economic, and environmental/technological variables and physician variables has long been recognized in the medical-sociological literature (Anderson and Marshall, 1974). However, attention to this aspect is notably lacking in the empirical literature. We suspect that traditional variables, although crucial in cross-sectional models of physician distribution might have lost their significance in models of change. Essentially, we ask to what extent do traditional patterns of physician distribution persist. This chapter is intended to address this and related issues. More specifically, in this investigation, causal models of change in physician distribution are developed and estimated incorporating three major domains of interest, namely, demographic, socio-economic, and environmental factors using the ecological framework.

The chapter is organized as follows: In section 7.1 some of the problems of measuring change and a brief description of reasons for using residualized change scores to estimate models are presented. The section also includes a discussion of bivariate and multivariate analyses of models of change in two categories of physicians: general practitioners and family physicians, and specialists. In section 7.2, we construct and analyze structural equation models for studying the causes of change in the two categories of physicians. Finally, a combined model involving these two categories is analyzed and discussed.

7.1 Models of Change: An Exploratory Analysis

While the ultimate goal is to ascertain the causal influence of various predictors for change in physician distribution, it is worth looking at the bivariate and multivariate relationships among variables first.

The principal objective of this section thus is to determine the extent to which changes in three broad factors - demographic, socio-economic, and environmental - affect changes in physician ratios over the period 1971 and 1981. This aspect will be taken up momentarily. However, before doing so, a brief overview of methods for analyzing change is in order.

7.1.1 Methods for Analyzing Change

One of the more frequently used methods to model change is by using first difference scores. Despite Liker and his colleagues (Liker et al. 1983) having pointed out that 'the method makes no allowance for the "regression-towards-the-mean" effects between Time 1 and Time 2', a great deal of research employing the method is observable.

Another frequently used method for modelling change is by interpreting conventional regression equations involving static scores at two time points and, thereby avoiding computation of explicit change scores (Markus, 1979; Kessler and Greenberg, 1981; Headey et al. 1985). It is computed simply as:

$$SPP_2 = a+b_1SPP_1+b_2BED_1+b_3BED_2+e \qquad (7.1-1)$$

where BED is a variable that influences SPP, and e is an error term. The coefficient b_3 represents the amount of change in SPP at Time 2 produced by one unit change in BED at Time 2, controlling for SPP and BED at Time 1.

Certain criticisms (see Kessler and Greenberg, 1981:11) have been raised of this method including the following:

(1) Although the effects of "regression-towards-the-mean"

resulting from random measurement error are partialled out, the method does not differ mathematically from that involving first-difference score; and

(2) A problem of multicollinearity arises when measures of variables at two time points are simultaneously entered into the equation.

The methodological difficulties accruing to the regression method just discussed are currently calling forth additional methodological contributions. More recently, studies have appeared that employed predicted scores of variables at Time 2 to model change. The method has been termed the 'residualized change score method' (see Heady et al., 1985). The residualized change scores are calculated as follows.

The measures of variables at Time 2 are first regressed on the measures at Time 1 in order to get predicted scores at Time 2. The residualized change scores are then obtained by subtracting the predicted scores from the actual scores. For example,

$$\widetilde{BED}_2 = a+b_1 BED_1 \qquad (7.1\text{-}2)$$

$$\Delta BED = BED_2-\widetilde{BED}_2 \qquad (7.1\text{-}3)$$

where ΔBED is the residualized change score for BED. As Heady and his colleagues (1985:274) have suggested, "the residualized change scores eliminate multicollinearity problems because Time 1 and Time 2 scores are no longer both included on the right hand side of equations" as is the case in equation 7.1-1. Although the method appears to be superior, in comparision with the other two methods, it has been used rather infrequently in modelling change. This study employs this procedure to model change.

7.1.2 Bivariate Relationships among Change Variables

A preliminary assessment of the relationships of interest is possible with the information provided in Table 7.1-1 where the zero-order correlation matrix for the change scores is presented. As the results in Table 7.1-1 indicate, change in general practitioners and family physicians (ΔGFP) relates strongly to change in population under 5 years (ΔCHD) and education (ΔEDU). The effects of changes in hospital beds (ΔBED) and owner-occupied dwellings (ΔOOD) are minimal ($r=0.068$ and $r=-0.070$ respectively). ΔGEP is not significantly related to change in hospital beds and physician ratios. Therefore, this variable is dropped from further analyses. Perhaps, the most important message that emerges from the table is that change in hospital beds (ΔBED) does not stand out as a predictor of change in general practitioners and family physicians (ΔGFP), a finding that is consistent with cross-sectional models.

Table 7.1-1

Zero-order Correlations among the Variables Used in the Change Model[1]

	ΔSPP	ΔGFP	ΔBED	ΔPOP	ΔCHD	ΔOLD	ΔNAT	ΔEDU	ΔOOD	ΔGEP
ΔSPP	1.000									
ΔGFP	0.268**	1.000								
ΔBED	0.183*	0.068	1.000							
ΔPOP	0.488**	0.107	0.034	1.000						
ΔCHD	-0.320**	-0.242**	0.027	-0.244**	1.000					
ΔOLD	-0.046	0.095	0.053	-0.091	-0.531**	1.000				
ΔNAT	-0.154	0.093	0.064	-0.064	0.406**	-0.141	1.000			
ΔEDU	0.578**	0.188*	-0.028	0.429**	-0.156	-0.155	-0.029	1.000		
ΔOOD	0.557**	-0.070	-0.318**	-0.450**	0.115	0.244**	-0.010	-0.285**	1.000	
ΔGEP	-0.044	0.052	0.025	-0.200*	-0.310**	0.321**	-0.370**	-0.102	0.112	1.000

[1] Residualized change scores were employed.
* Significant at the 0.01 level
** significant at the 0.001 level

Turning to the second column of Table 7.1-1 we see that all the variables, with the exception of change in population 65 years and older (ΔOLD) and change in native population (ΔNAT) relate strongly to change in specialists (ΔSPP). Changes in education (ΔEDU) and owner-occupied dwellings (ΔOOD) are, in particular, strongly related to change in specialist distribution. However, the prevalence of statistically significant bivariate relationships among the predictors raises the likelihood that the association(s) of physician variable(s) with a single independent variable may be spurious. Attention, therefore, must focus on changes in these factors while controlling for the impact of changes in other factors before a firm conclusion is made. This can be accomplished by examining the results of multivariate analyses.

7.1.3 Multivariate Relationships among Change Variables

In order to shed additional light on the independent variables impact on physician variables due to change, we also investigated hierarchical multiple regressions. Separate regression analyses are run for general practitioners and family physicians, and specialists with all seven variables included in each equation. A third regression analysis is run for hospital beds with the six predictor variables. Table 7.1-2 reports the results of these analyses. For simplicity, the change variables are

Table 7.1-2

Results of Multiple Regression Analyses with Change in Physician/Population Ratios and Hospital Bed/Population Ratios as Dependent Variables, Canadian Census Divisions, 1971-81

Independent	ΔGFP		ΔSPP		ΔBED	
Variables'	B	Beta	B	Beta	B	Beta
ΔPOP	-0.175	-0.016	1.627	0.112*	-1.799	-0.078
ΔCHD	-8.661	-0.349**	-5.014	-0.149**	9.097	0.170*
ΔOLD	-0.476	-0.052	0.226	0.018	4.711	0.239**
ΔNAT	1.068	0.226**	-0.518	-0.081	0.181	0.018
ΔEDU	0.930	0.156**	3.330	0.409**	-0.756	-0.059
ΔOOD	0.139	0.049	-1.350	-0.350**	-2.744	-0.448**
ΔBED	0.040	0.086	0.055	0.087	-	–
Constant	1.287		-5.356		0.769	
R^2(adjusted)	0.097		0.544		0.132	
SE	26.986		26.085		57.196	
F	3.882		33.097		5.774	

' The variables that met the selection criteria (F-to-enter=1.0 and Tolerance level=0.05) for ΔGFP, ΔSPP, and ΔBED are: ΔCHD, ΔNAT, and ΔEDU; ΔCHD, ΔEDU and ΔOOD; and ΔCHD, ΔOLD, and ΔOOD;

* Coefficient at least 1.5 times standard error
** Coefficient at least twice its standard error

hereafter referred by their mnemonic labels.

The results presented in Table 7.1-2 strongly reaffirm the conclusions drawn from the bivariate analysis. In general, ΔCHD and ΔEDU do predict changes in general practitioners and family physicians (ΔGFP) strongly (β=-0.347 and 0.175 respectively). Unlike the bivariate associations, however, the regression coeffcient for ΔNAT shows that this variable significantly predicts (β=0.226) change in general practitioners and family physicians (ΔGFP).

The variable ΔCHD explains the greatest share of the variance, 6.0 percent. Recall that in the static model at Time 1, it is population size, that enters the equation first, explaining 38.0 percent of the variance in general practitioners and family physicians. In the model at Time 2, it is education, that enters the equation first, explaining 4.0 percent of the variance.

The low R^2's (R^2=0.131; R^2(adj)=0.097) pose some concern, specifically, as neither the present regression nor the regression at Time 2 fit the data very well. As mentioned in the beginning of this chapter, one could not expect to find that traditionally important predictors explain much variation in physician ratios if differentials, especially in demographic factors, between areas are disappearing.

In examining the results for specialists, we see that ΔPOP, ΔCHD, ΔEDU, and ΔOOD are significant determinants of change in specialist distribution (ΔSPP). The results support the importance of change in socio-economic variables in determining change in specialist supply. The two variables ΔEDU and ΔOOD by themselves account for 50.0 percent of the variation in specialist distribution when the final prediction equation accounts for 56.1 percent of the variance (R^2(adj)=0.544). Our hypotheses concerning the relationship between specialists and ΔOLD and ΔNAT have not found support in this analysis.

The predictive ability of the model is much higher for specialists than it is for general practitioners and family physicians. In the general practitioners and family physicians model, 13.1 percent of the variance is explained, and the statistically significant predictors are ΔCHD, ΔNAT, and ΔEDU. In the specialist model 56.1 percent of the variance is explained, with the significant predictors being ΔPOP, ΔCHD, ΔEDU, and ΔOOD. Overall, then, the results suggest that potential contributors of change in physician distribution vary among physician groups.

For hospital beds (Table 7.1-2), the statistically significant predictors in order of their explanatory importance are ΔOOD, ΔOLD, and ΔCHD. Almost two-thirds of the total variance (10.1%) is explained by the first of these three variables while the model as a whole explains 16.0 percent of the variance in change in hospital beds (R^2(adj)=0.130). Contrary to expectations, ΔPOP, ΔNAT, and ΔEDU are not significant predictors of change in hospital beds (ΔBED) once other variables are controlled.

In summary, the multivariate analyses identified a set of independent variables that emerge as relatively important predictors of changes in physician ratios. The relationship of these independent variables to the physician variables may be mediated by change in hospital beds. Further research is necessary to clarify the mechanisms by which change in hospital beds may influence changes in general(family) practitioners and specialists distribution. For this reason, more comprehensive causal modelling such as structural equation modelling seems appropriate in assessing factors affecting the change in physician distribution as a consequence of change in population, socio-economic and environmental/technological factors.

7.2 Causal Models of Change in Physician Distribution

In this section, we specify, estimate and discuss the causal models of change in general(family) practitioners and specialists and a combined model including the two. As a starting point for estimating the models, the specification of the three models are discussed. The subsections 7.2.2 through 7.2.4 focus on the results of the LISREL analyses of the three models.

7.2.1 Specification of Models of Change

The model depicted in Figure 7.2-1 indicates that ΔPOP, ΔCHD, ΔOLD, ΔEDU, and ΔOOD affect changes in hospital beds (ΔBED) directly and general practitioners and family physicians (ΔGFP) indirectly via ΔBED. ΔCHD, ΔOLD, ΔNAT, ΔEDU, and ΔOOD affect general practitioners and family physicians (ΔGFP) directly. According to the model, ΔBED has a direct effect on change in general practitioners and family physicians (ΔGFP).

The model shown in Figure 7.2-1 corresponds to the following system of structural equations:

$\Delta POP \equiv \xi_1$ (ksi sub 1) $\Delta GFP \equiv \eta_1$ (eta sub 1)

$\Delta CHD \equiv \xi_2$ (ksi sub 2) $\Delta BED \equiv \eta_2$ (eta sub 2)

$\Delta OLD \equiv \xi_3$ (ksi sub 3)

$\Delta NAT \equiv \xi_4$ (ksi sub 4)

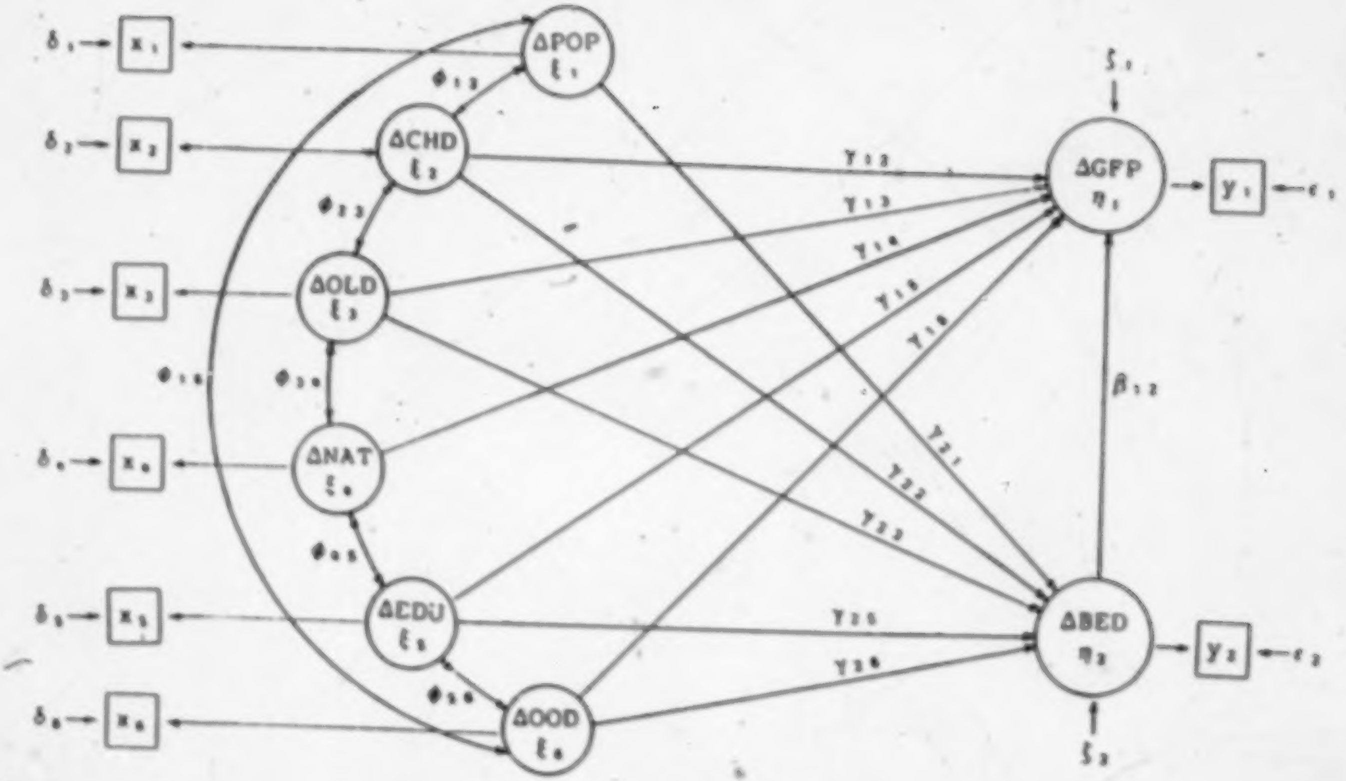

ΔPOP ξ_1
ΔCHD ξ_2
ΔOLD ξ_3
ΔNAT ξ_4
ΔEDU ξ_5
ΔOOD ξ_6
ΔGFP η_1
ΔBED η_2
δ_1
δ_2
δ_3
δ_4
δ_5
δ_6
x_1
x_2
x_3
x_4
x_5
x_6
y_1
y_2
ϵ_1
ϵ_2
ζ_1
ζ_2
ϕ_{12}
ϕ_{23}
ϕ_{34}
ϕ_{45}
ϕ_{56}
ϕ_{16}
γ_{12}
γ_{13}
γ_{14}
γ_{15}
γ_{16}
γ_{21}
γ_{22}
γ_{23}
γ_{25}
γ_{26}
β_{12}

Figure 7.2-1 The Causal Diagram Describing Effects of Change in Demographic, Socio-economic, and Environmental Factors on General (Family) Practitioners Distribution at Time 1

ΔEDU ≡ ξ_5 (ksi sub 5)

ΔOOD ≡ ξ_6 (ksi sub 6)

$$\begin{bmatrix}\eta_1\\ \eta_2\end{bmatrix}=\begin{bmatrix}0 & \beta_{12}\\ 0 & 0\end{bmatrix}\begin{bmatrix}\eta_1\\ \eta_2\end{bmatrix}+\begin{bmatrix}0 & \gamma_{12} & \gamma_{13} & \gamma_{14} & \gamma_{15} & \gamma_{16}\\ \gamma_{21} & \gamma_{22} & \gamma_{23} & 0 & \gamma_{25} & \gamma_{26}\end{bmatrix}\begin{bmatrix}\xi_1\\ \xi_2\\ \xi_3\\ \xi_4\\ \xi_5\\ \xi_6\end{bmatrix}+\begin{bmatrix}\zeta_1\\ \zeta_2\end{bmatrix} \quad (7.2\text{-}1)$$

Recall from the discussion in Chapter 6 that theoretical constructs are related to observed indicators through correspondence rules. Thus, the unobserved theoretical constructs η's and ξ's can be related to observed indicators Y's and X's respectively as follows:

$$\begin{bmatrix}y_1\\ y_2\end{bmatrix}=\begin{bmatrix}1 & 0\\ 0 & 1\end{bmatrix}\begin{bmatrix}\eta_1\\ \eta_2\end{bmatrix}+\begin{bmatrix}\epsilon_1\\ \epsilon_2\end{bmatrix} \quad (7.2\text{-}2)$$

and

$$\begin{bmatrix}x_1\\ x_2\\ x_3\\ x_4\\ x_5\\ x_6\end{bmatrix}=\begin{bmatrix}1&0&0&0&0&0\\ 0&1&0&0&0&0\\ 0&0&1&0&0&0\\ 0&0&0&1&0&0\\ 0&0&0&0&1&0\\ 0&0&0&0&0&1\end{bmatrix}\begin{bmatrix}\xi_1\\ \xi_2\\ \xi_3\\ \xi_4\\ \xi_5\\ \xi_6\end{bmatrix}+\begin{bmatrix}\delta_1\\ \delta_2\\ \delta_3\\ \delta_4\\ \delta_5\\ \delta_6\end{bmatrix} \quad (7.2\text{-}3)$$

The variance-covariance matrices of ξ and ζ are respectively,

$$\Phi = \begin{bmatrix} \phi_{11} & 0 & 0 & 0 & 0 & 0 \\ \phi_{21} & \phi_{22} & 0 & 0 & 0 & 0 \\ \phi_{31} & \phi_{32} & \phi_{33} & 0 & 0 & 0 \\ \phi_{41} & \phi_{42} & \phi_{43} & \phi_{44} & 0 & 0 \\ \phi_{51} & \phi_{52} & \phi_{53} & \phi_{54} & \phi_{55} & 0 \\ \phi_{61} & \phi_{62} & \phi_{63} & \phi_{64} & \phi_{65} & \phi_{66} \end{bmatrix} \qquad (7.2\text{-}4)$$

$$\psi = \begin{bmatrix} \psi_{11} & 0 \\ 0 & \psi_{22} \end{bmatrix} \qquad (7.2\text{-}5)$$

The errors of measurement of y's and x's are respectively

$$\Theta_\epsilon = \begin{bmatrix} \theta_{\epsilon 11} & 0 \\ 0 & \theta_{\epsilon 22} \end{bmatrix} \qquad (7.2\text{-}6)$$

$$\Theta_\delta = \begin{bmatrix} \theta_{\delta 11} & 0 & 0 & 0 & 0 & 0 \\ 0 & \theta_{\delta 22} & 0 & 0 & 0 & 0 \\ 0 & 0 & \theta_{\delta 33} & 0 & 0 & 0 \\ 0 & 0 & 0 & \theta_{\delta 44} & 0 & 0 \\ 0 & 0 & 0 & 0 & \theta_{\delta 55} & 0 \\ 0 & 0 & 0 & 0 & 0 & \theta_{\delta 66} \end{bmatrix} \qquad (7.2\text{-}7)$$

The model shown in Figure 7.2-2 contains the same number of endogenous and exogenous variables. The structural relations specified by this model are different from that of the previous model, whereas the measurement

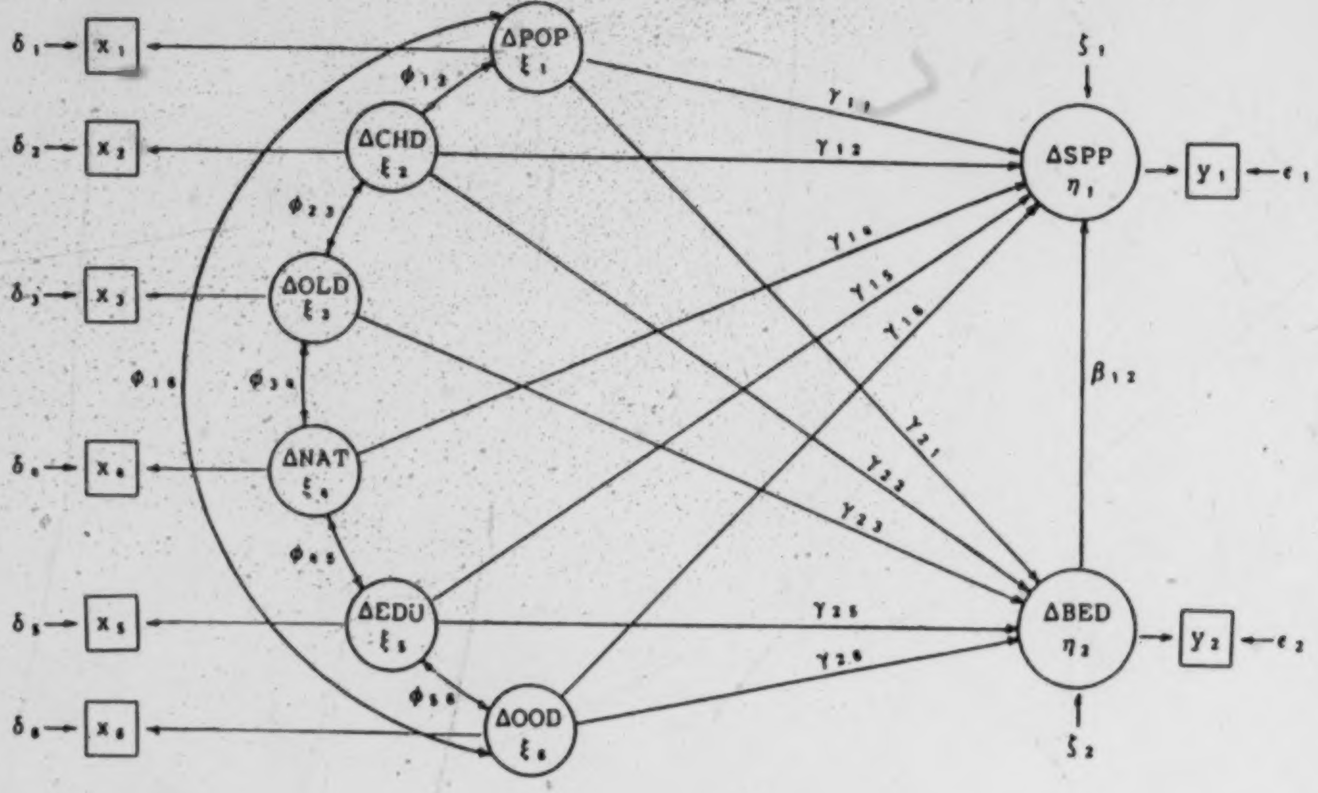

δ_1
x_1
δ_2
x_2
δ_3
x_3
δ_4
x_4
δ_5
x_5
δ_6
x_6
ΔPOP ξ_1
ΔCHD ξ_2
ΔOLD ξ_3
ΔNAT ξ_4
ΔEDU ξ_5
ΔOOD ξ_6
ϕ_{12}
ϕ_{23}
ϕ_{34}
ϕ_{16}
ϕ_{45}
ϕ_{56}
γ_{11}
γ_{12}
γ_{14}
γ_{15}
γ_{16}
γ_{21}
γ_{22}
γ_{23}
γ_{25}
γ_{26}
ζ_1
ΔSPP η_1
y_1
ϵ_1
β_{12}
ΔBED η_2
y_2
ϵ_2
ζ_2

Figure 7.2-2. The Causal Diagram Describing Effects of Changes in Demographic, Socio-economic, and Environmental Factors on Specialists Distribution at Time 1

equations remain the same. The model proposed here posits that ΔPOP, ΔCHD, ΔOLD, ΔEDU, and ΔOOD affect changes in hospital beds (ΔBED) directly and specialists (ΔSPP) indirectly via ΔBED. For specialists, the path from ΔOLD is omitted and a new path, namely, the path from ΔNAT is introduced. For this model, the structural relations are thus specified as:

$\Delta POP \equiv \xi_1$ (ksi sub 1) $\Delta SPP \equiv \eta_1$ (eta sub 1)
$\Delta CHD \equiv \xi_2$ (ksi sub 2) $\Delta BED \equiv \eta_2$ (eta sub 2)
$\Delta OLD \equiv \xi_3$ (ksi sub 3)
$\Delta NAT \equiv \xi_4$ (ksi sub 4)
$\Delta EDU \equiv \xi_5$ (ksi sub 5)
$\Delta OOD \equiv \xi_6$ (ksi sub 6)

$$\begin{bmatrix} \eta_1 \\ \eta_2 \end{bmatrix} = \begin{bmatrix} 0 & \beta_{12} \\ 0 & 0 \end{bmatrix} \begin{bmatrix} \eta_1 \\ \eta_2 \end{bmatrix} + \begin{bmatrix} \gamma_{11} & \gamma_{12} & 0 & \gamma_{14} & \gamma_{15} & \gamma_{16} \\ \gamma_{21} & \gamma_{22} & \gamma_{23} & 0 & \gamma_{25} & \gamma_{26} \end{bmatrix} \begin{bmatrix} \xi_1 \\ \xi_2 \\ \xi_3 \\ \xi_4 \\ \xi_5 \\ \xi_6 \end{bmatrix} + \begin{bmatrix} \zeta_1 \\ \zeta_2 \end{bmatrix} \qquad (7.2\text{-}8)$$

According to the model presented in Figure 7.2-3, changes in demographic and socio-economic factors lead to changes in hospital beds, which, in turn lead to changes in general(family) practitioners and specialists. Further, changes in general(family) practitioners and specialists

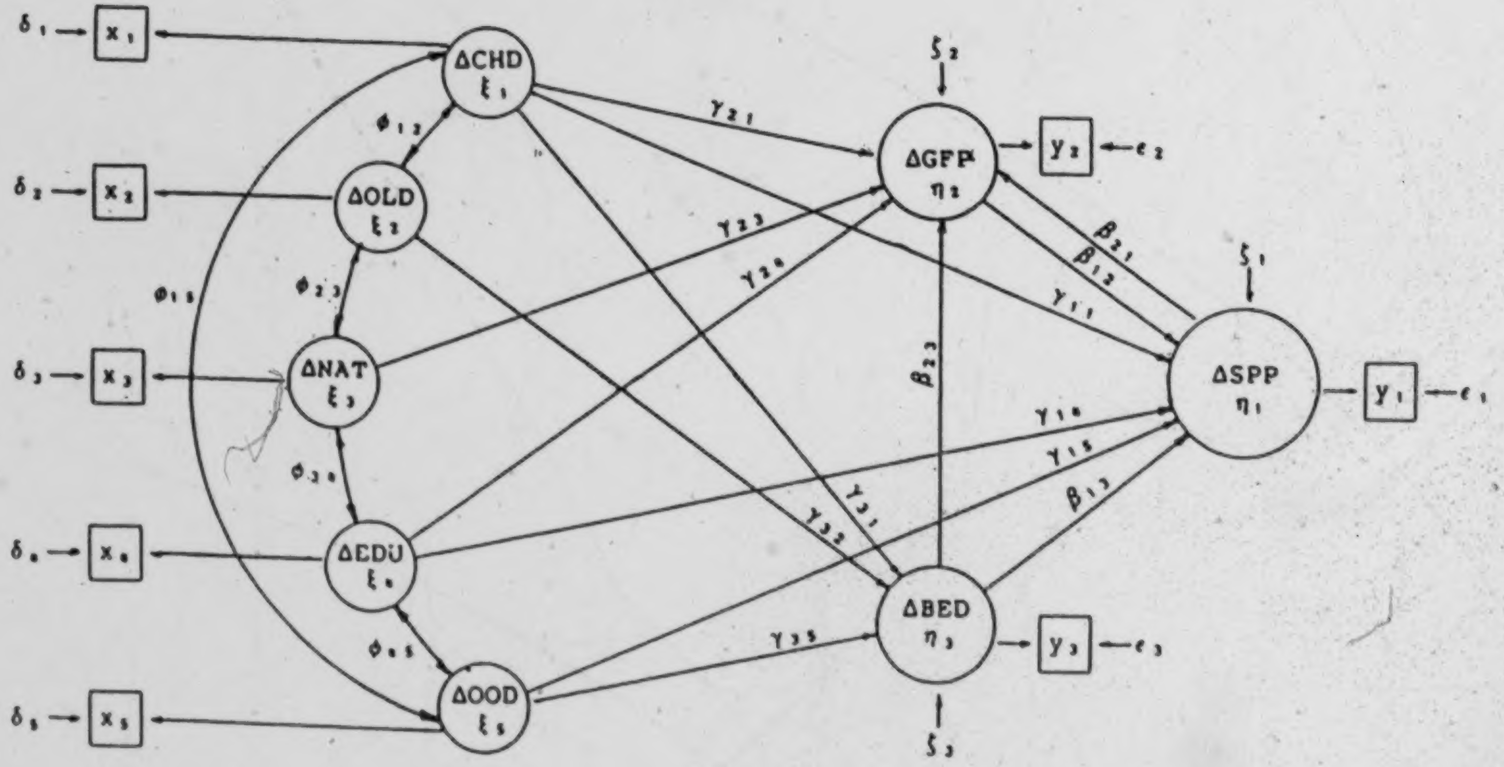

δ1
x1
δ2
x2
δ3
x3
δ4
x4
δ5
x5
ΔCHD ξ1
ΔOLD ξ2
ΔNAT ξ3
ΔEDU ξ4
ΔOOD ξ5
φ12
φ23
φ34
φ45
φ15
γ21
γ23
γ24
γ31
γ32
γ35
γ11
γ14
γ15
β21
β12
β23
β13
ζ2
ζ1
ζ3
ΔGFP η2
ΔSPP η1
ΔBED η3
y2
y1
y3
ε2
ε1
ε3

Figure 7.2-3 The Causal Diagram Describing Effects of Change in Demographic, Socio-economic, and Environmental Factors on General (Family) Practitioners and Specialists Distribution at Time 1

affect one another. Although the two models described above confirm the first and second of these steps separately, it is important to unify these two processes into a combined model in order to examine the so-called 'substitution effect'. It might be argued, for example, that the predictors of change in general practitioners and family physicians may have indirect effects on changes in specialists that may operate through change in general(family) practitioners. Thus an additional set of analyses is conducted in which both general(family) practitioners and specialists are included in a single model as diagrammed in Figure 7.2-3.

According to the model, ΔCHD, ΔNAT, and ΔEDU affect changes in general practitioners and family physicians (ΔGFP) directly and specialists (ΔSSP) indirectly via ΔGFP. These variables with the exception of ΔNAT along with ΔOOD affect change in specialists (ΔSPP) directly. And ΔCHD, ΔOLD, and ΔOOD affect change in specialists (ΔSPP) indirectly via ΔBED. As Figure 7.2-3 indicates, change in hospital beds (ΔBED) and general practitioners and family physicians (ΔGFP) also affect change in specialists (ΔSPP) directly. General practitioners and family physicians (ΔGFP), in turn, are affected by change in specialists (ΔSPP) and change in hospital beds ΔBED.

The matrices for the structural and measurement models consistent with Figure 7.2-3 are:

ΔCHD ≡ ξ_1 (ksi sub 1)   ΔSPP ≡ η_1 (eta sub 1)
ΔOLD ≡ ξ_2 (ksi sub 2)   ΔGFP ≡ η_2 (eta sub 2)
ΔNAT ≡ ξ_3 (ksi sub 3)   ΔBED ≡ η_3 (eta sub 3)
ΔEDU ≡ ξ_4 (ksi sub 4)
ΔOOD ≡ ξ_5 (ksi sub 5)

$$\begin{bmatrix}\eta_1\\ \eta_2\\ \eta_3\end{bmatrix} = \begin{bmatrix}0 & \beta_{12} & \beta_{13}\\ \beta_{21} & 0 & \beta_{23}\\ 0 & 0 & 0\end{bmatrix}\begin{bmatrix}\eta_1\\ \eta_2\\ \eta_3\end{bmatrix} + \begin{bmatrix}\gamma_{11} & 0 & 0 & \gamma_{14} & \gamma_{15}\\ \gamma_{21} & 0 & \gamma_{23} & \gamma_{24} & 0\\ \gamma_{31} & \gamma_{32} & 0 & 0 & \gamma_{35}\end{bmatrix}\begin{bmatrix}\xi_1\\ \xi_2\\ \xi_3\\ \xi_4\\ \xi_5\end{bmatrix} + \begin{bmatrix}\zeta_1\\ \zeta_2\\ \zeta_3\end{bmatrix} \tag{7.2-9}$$

$$\begin{bmatrix}y_1\\ y_2\\ y_3\end{bmatrix} = \begin{bmatrix}1 & 0 & 0\\ 0 & 1 & 0\\ 0 & 0 & 1\end{bmatrix}\begin{bmatrix}\eta_1\\ \eta_2\\ \eta_3\end{bmatrix} + \begin{bmatrix}\epsilon_1\\ \epsilon_2\\ \epsilon_3\end{bmatrix} \tag{7.2-10}$$

$$\begin{bmatrix}x_1\\ x_2\\ x_3\\ x_4\\ x_5\end{bmatrix} = \begin{bmatrix}1 & 0 & 0 & 0 & 0\\ 0 & 1 & 0 & 0 & 0\\ 0 & 0 & 1 & 0 & 0\\ 0 & 0 & 0 & 1 & 0\\ 0 & 0 & 0 & 0 & 1\end{bmatrix}\begin{bmatrix}\xi_1\\ \xi_2\\ \xi_3\\ \xi_4\\ \xi_5\end{bmatrix} + \begin{bmatrix}\delta_1\\ \delta_2\\ \delta_3\\ \delta_4\\ \delta_5\end{bmatrix} \tag{7.2-11}$$

$$\Phi = \begin{bmatrix} \phi_{11} & 0 & 0 & 0 & 0 \\ \phi_{21} & \phi_{22} & 0 & 0 & 0 \\ \phi_{31} & \phi_{32} & \phi_{33} & 0 & 0 \\ \phi_{41} & \phi_{42} & \phi_{43} & \phi_{44} & 0 \\ \phi_{51} & \phi_{52} & \phi_{53} & \phi_{54} & \phi_{55} \end{bmatrix} \qquad (7.2\text{-}12)$$

$$\Psi = \begin{bmatrix} \psi_{11} & 0 & 0 \\ 0 & \psi_{22} & 0 \\ 0 & 0 & \psi_{33} \end{bmatrix} \qquad (7.2\text{-}13)$$

$$\Theta_\epsilon = \begin{bmatrix} \theta_{\epsilon 11} & 0 & 0 \\ 0 & \theta_{\epsilon 22} & 0 \\ 0 & 0 & \theta_{\epsilon 33} \end{bmatrix} \qquad (7.2\text{-}14)$$

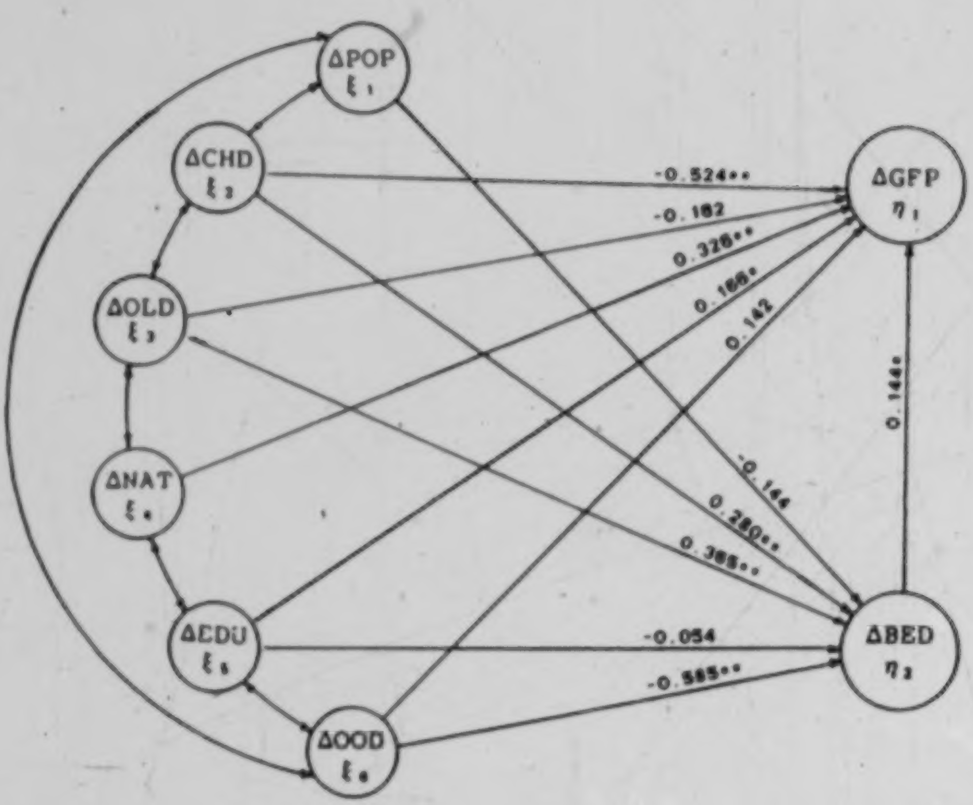
$$\Theta_\delta = \begin{bmatrix} \theta_{\delta 11} & 0 & 0 & 0 & 0 \\ 0 & \theta_{\delta 22} & 0 & 0 & 0 \\ 0 & 0 & \theta_{\delta 33} & 0 & 0 \\ 0 & 0 & 0 & \theta_{\delta 44} & 0 \\ 0 & 0 & 0 & 0 & \theta_{\delta 55} \end{bmatrix} \qquad (7.2\text{-}15)$$

This completes the specification of models of change. One variance-covariance matrix was used as input for the estimation of all the three models and is presented in Appendix Table C-1.

7.2.2 Model of Change in General (Family) Practitioners Physicians

The results of the LISREL analysis of the model in Figure 7.2-1 are presented in Figure 7.2-4 and Table 7.2-1. The correlations among the exogenous variables are presented in Table 7.2-2. The model fits the data exceedingly well: $\chi^2=0.19$ with 2 degrees of freedom and the probability associated with chi-square is 0.910. The GFI = 1.0 which further indicates acceptance of the model. Other standard indicators such as the size of the residuals and the first-order derivatives are also examined. The maximum value of the residual is as small as 0.278 suggesting that no constraint need to be relaxed (Appendix Table C-2). The first-order derivatives of all the constrained parameters are zero indicating a perfect fit (Appendix Table C-3).

Table 7.2-1 contains the R^2s, the squared multiple correlations for the structural equations. The values for R^2 indicate that changes in exogenous variables explain 21.0 percent of the variation in change for general(family) practitioners and approximately 25.0 percent of the variance in change in hospital beds. These suggest the existence of unmeasured exogenous variable(s) that affect changes in both general(family) practitioners and hospital beds. This is also indicated by high values



ΔPOP
ξ_1
ΔCHD
ξ_2
ΔOLD
ξ_3
ΔNAT
ξ_4
ΔEDU
ξ_5
ΔOOD
ξ_6
ΔGFP
η_1
ΔBED
η_2
-0.524**
-0.182
0.326**
0.166*
0.142
0.144*
-0.144
0.280**
0.388**
-0.054
-0.585**

Figure 7.2-4 The Causal Diagram of the Change in General (Family) Practitioners Model with Standardized Parameters as Estimated by LISREL

* Parameter is more than 1.5 times its standard error
** Parameter is more than twice its standard error

Table 7.2-1

Metric and Standardized' Structural Coefficients and Goodness-of-fit Measures for the Model of Change in General (Family) Practitioners

	ΔGFP	ΔBED	ΔPOP	ΔCHD	ΔOLD	ΔNAT	ΔEDU	ΔOOD	R^2	PSI
ΔGFP	0.000* (0.000)	0.067 (0.144)	0.000* (0.000)	-12.256 (-0.524)	-1.396 (-0.162)	1.491 (0.326)	0.962 (0.166)	0.379 (0.142)	0.207	0.793
ΔBED	0.000* (0.000)	0.000* (0.000)	-2.483 (-0.114)	14.155 (0.280)	6.787 (0.365)	0.000* (0.000)	-0.682 (-0.054)	-3.379 (-0.585)	0.248	0.752

χ^2=0.19 D.F.=2 P=0.910 GFI=1.000 AGFI=0.995 RMSR=0.984 Max NR=0.278 Max MI=0.17**

R^2 = Squared Multiple Correlations for Structural Equations
PSI = Covariances among the ζ Error Terms
χ^2 = CHI Square
D. F. = Degrees of Freedom
GFI = Goodness-of-Fit Index
AGFI = Adjusted Goodness-of-Fit Index
RMSR = Root Mean Square Residual Correlation
Max NR = Maximum Normalized Residual
Max MI = Maximum Modification Index

' Standardized Coefficients in parentheses
* The parameter is constrained to zero.
** Warrants no further reduction of constraints in the Model is needed.

Table 7.2-2

PHI Matrix (Covariance Matrix of Exogenous Variables) for the Models of Change in Physician Distribution'

	ΔPOP	ΔCHD	ΔOLD	ΔNAT	ΔEDU	ΔOOD
ΔPOP	1.000					
ΔCHD	-0.270	1.000				
ΔOLD	-0.101	-0.590	1.000			
ΔNAT	-0.074	0.464	-0.161	1.000		
ΔEDU	0.489	-0.178	-0.178	-0.034	1.000	
ΔOOD	-0.500	0.128	0.272	-0.011	-0.326	1.000

'The PHI Matrices are the same for all the three models for the PSI's (the standardized variance of the residuals).

As Table 7.2-1 indicates, ΔCHD, ΔNAT, and ΔEDU all have significant effects on change in general practitioners and family physicians (ΔGFP). Areas that have experienced an increase in the proportion of children under 5 years have not experienced an increase in general practitioners and family physicians (-0.484) to meet the additional demand while areas that experienced an increase in the proportion of native population and proportion of university educated persons have gained their supply of general practitioners and family physicians.

ΔCHD, ΔOLD, and ΔOOD have significant direct effects on ΔBED. In this case, areas experiencing an increase in the young and old populations are more likely to experience an increase in hospital bed supply. Consistent with our findings from static models; areas that have experienced an increase in the number of owner-occupied dwellings have not experienced an increase in the number of hospital beds. Similarly, an increase in population did not contribute to an increase in hospital bed supply. This suggests that population growth outstrips allocation of hospital beds and, in some cases fail to meet actual need.

Change in hospital bed ratios have relatively little impact on change in general(family) practitioners ratios (0.144). This is wholly inconsistent with the existing belief that an increase in hospital beds would bring about an increase in physicians in under-serviced areas. For example, in his analysis using cross-sectional data, Marden (1966) found an inverse relationship between general(family) practitioners and hospital beds in some areas (areas with a population of under 50,000).

Hospital beds, with few exceptions, do not appear to intervene between demographic and socio-economic variables, and general(family) practitioners. This is evident when the direct, indirect and total causal effects of variables are examined (Table 7.2-3). However, one may observe that more than 1.5 times the impact of owner occupied dwellings and one-third of the impact of population 65 years and older operate through hospital beds. Hence while change in hospital bed supply appears to have some immediate consequence for change in general(family) practitioner supply, such a change is also caused by the sociodemographic structure of the population being served.

Table 7.2-3

Decomposition Effects of Endogenous and Exogenous Variables for th-' e Model of Change in General (Family) Practitioners

Variables	ΔGFP			ΔBED
	Direct	Indirect	Total	Direct(Total)
ΔGFP	0.000*	0.000*	0.000*	0.000*
ΔBED	0.144	0.000*	0.144	0.000*
ΔPOP	0.000*	-0.017	-0.017	-0.114
ΔCHD	-0.524	0.040	-0.484	0.280
ΔOLD	-0.162	0.052	-0.110	0.365
ΔNAT	0.326	0.000*	0.326	0.000*
ΔEDU	0.166	-0.008	0.158	-0.054
ΔOOD	0.142	-0.085	0.057	-0.585

' These are standardized coefficients.
* The parameters are constrained to zero.

7.2.3 Model of Change in Specialists

Table 7.2-4 presents goodness-of-fit statistics, and metric and standardized parameter estimates of the LISREL analysis of specialists. The likelihood ratio chi-square value for the model is 0.30 with 2 degrees of freedom, indicating that the model is consistent with the data. The residuals listed in Appendix Table C-5 suggest that the values are small and insignificant (maximum value = 0.196). The first-order derivatives for the constrained parameters are all either zero or close to zero suggesting that the specification of the model needs no further revision.

The model accounts for 76 percent of the variance in specialists and approximately 25 percent of the variance in hospital beds. Obviously, these findings suggest that there is no room for further improvement in the specification of the first equation whereas much improvement can be done in the specification of the second equation. For the intervening variable, hospital beds, the proportion of unexplained variance is relatively high (PSI = 0.752) and the variable is not adequately explained by the theory.

The standardized coefficients for the model are presented in Figure 7.2-5. The model contains only few

Table 7.2-4

Metric and Standardized' Structural Coefficients and Goodness-of-Fit Measures for the Model of Change in Specialists

	ΔSPP	ΔBED	ΔPOP	ΔCHD	ΔOLD	ΔNAT	ΔEDU	ΔQOD	R^2	PSI
ΔSPP	0.000* (0.000)	0.070 (0.111)	0.981 (0.072)	-5.791 (-0.182)	0.000* (0.000)	-0.569 (-0.091)	3.987 (0.505)	-1.419 (-0.390)	0.762	0.238
ΔBED	0.000* (0.000)	0.000* (0.000)	-2.395 (-0.110)	14.201 (0.281)	6.795 (0.365)	0.000* (0.000)	-0.718 (-0.057)	-3.369 (-0.583)	0.248	0.752

$\chi^2=0.30$ D.F.=2 P=0.861 GFI=1.000 AGFI=0.993 RMSR=0.655 Max NR=0.196 Max MI=0.30**

R^2 = Squared Multiple Correlations for Structural Equations
PSI = Covariances among the ζ Error Terms
χ^2 = CHI Square
D. F. = Degrees of Freedom
GFI = Goodness-of-Fit Index
AGFI = Adjusted Goodness-of-Fit Index
RMSR = Root Mean Square Residual Correlation
Max NR = Maximum Normalized Residual
Max MI = Maximum Modification Index

' Standardized Coefficients in parentheses
* The parameter is constrained to zero.
** Warrants no further reduction of constraints in the Model is needed.

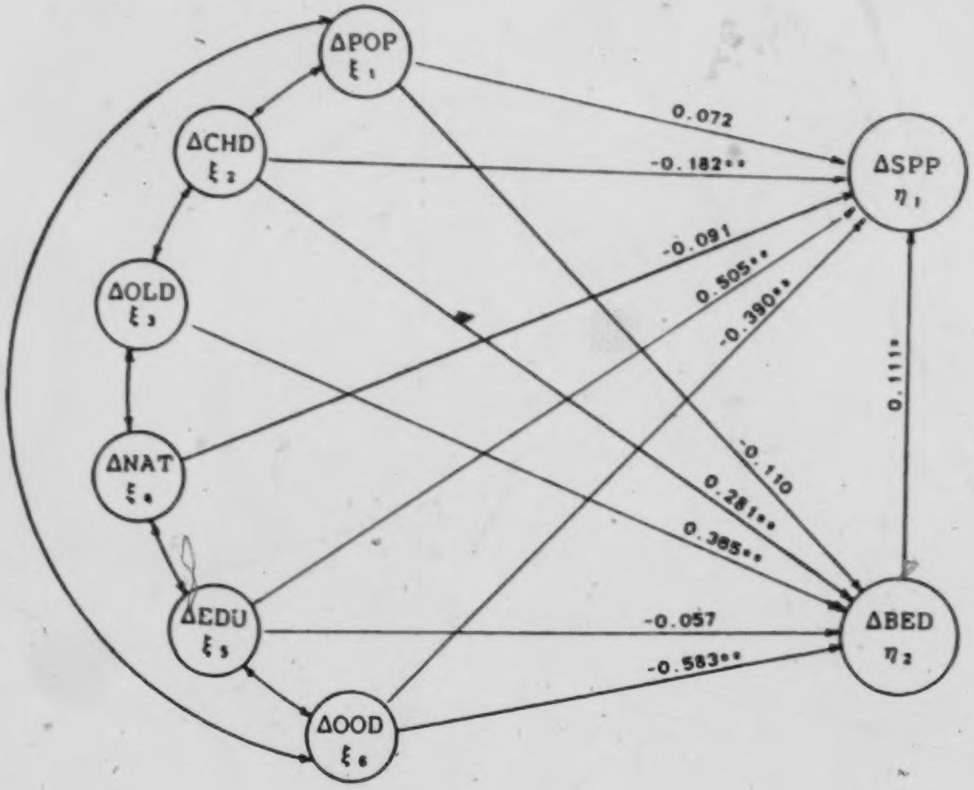

ΔPOP ξ_1
ΔCHD ξ_2
ΔOLD ξ_3
ΔNAT ξ_4
ΔEDU ξ_5
ΔOOD ξ_6
ΔSPP η_1
ΔBED η_2
0.072
-0.182**
-0.091
0.505**
-0.390**
-0.110
0.281**
0.385**
-0.057
-0.583**
0.111*

Figure 7.2-5. The Causal Diagram of the Changes in Specialists with Standardized Parameters as Estimated by LISREL

* Parameter is more than 1.5 times its standard error
** Parameter is more than twice its standard error

paths that are statistically insignificant: that between ΔPOP and ΔSPP (γ_{11} = 0.072); ΔNAT and ΔSPP (γ_{14} = -0.091); ΔPOP and ΔBED (γ_{21} = -0.110); and ΔEDU and ΔBED (γ_{25} = -0.057). In sum, on the basis of this evidence, one can conclude that change in population size has very little direct effect on specialist or hospital bed supply.

The variable ΔEDU has the strongest effect (0.505) on specialists. Thus, an increase in the population who are university educated is more likely to lead to an increase in demand for medical care and hence an increase in supply of specialists in aggregate. Overall, then, socio-economic rather than demographic factors have immediate consequence for altering specialist supply. Clearly, on the basis of this evidence, there is little reason to believe that an increase in the supply of physicians (specialists) occured in areas experiencing population growth. This is not to say that a change in physician supply is not responsive to demographic factors, but, rather, that it is more responsive to socioeconomic conditions.

Of the determinants of change in hospital beds (ΔBED), ΔOOD is by far the most important (-0.583). Areas experiencing an increase in the proportion of owner-occupied dwellings are not likely to gain hospital facilities and hence physician stock. It is possible that this measure of housing reflects an aspect of socio-economic conditions which would lower hospital utilization rates. Regardless of how the variable is conceived, there is sufficient evidence to support the hypothesis that owner-occupied dwellings is a key predictor of physician distribution and tends to be more important in explaining the variance in hospital bed supply than other socio-cultural variables. The static and change models provide strong supports for this argument. It can be argued that large commercial centres tend to have heavy concentration of physicians whereas the peripheral suburban residential centres tend to have an insufficient supply of physicians.

Turning to hospital beds, we see a statistically significant positive pattern (0.111) of association with change in specialists. This result leads us to expect that an increase in hospital bed supply might be followed by an increase in specialist supply in the area.

Table 7.2-5 presents the decomposition effects of variables. One may note that change in the proportion of ΔOOD has a strong effect on hospital beds and thus this variable has a rather strong indirect effect (-0.065). The direct effect of ΔOLD on specialists is assumed here to be zero, but the indirect effect is reasonably large, since this variable has quite strong effects on the intervening variable, hospital beds. Not conforming to our

Table 7.2-5

Decomposition Effects of Endogenous and Exogenous Variables for the Model of Change in Specialists

Variables	ΔSPP			ΔBED
	Direct	Indirect	Total	Direct(Total)
ΔSPP	0.000*	0.000*	0.000*	0.000*
ΔBED	0.111	0.000*	0.111	0.000*
ΔPOP	0.072	-0.012	0.060	-0.110
ΔCHD	-0.182	0.031	-0.151	0.281
ΔOLD	0.000*	0.041	0.041	0.365
ΔNAT	-0.091	0.000*	-0.091	0.000*
ΔEDU	0.505	-0.006	0.499	-0.057
ΔOOD	-0.390	-0.065	-0.455	-0.583

' These are standardized coefficients.
* The parameters are constrained to zero.

expectations, however, is the virtual unimportance of population size in the overall process. Further, in a statistical sense, hospital beds do not appear to play a crucial intervening role in translating changing demographic and socio-economic conditions into actual change in physician distribution. However, the consideration of both direct and indirect effects demonstrates the importance of the joint influence of variables such as owner-occupied dwellings and environmental factors, although the results lend clear support to the conclusion that it is not essential to separate environmental/technological factors from demographic or socio-economic factors, in a causal sense.

7.2.4 Combined Model of Change

It is possible that change in general(family) practitioners will have subsequent effects on changes in specialists and that change in specialists will affect change in general(family) practitioners. In attempting to address this issue, a combined model involving the two categories of physicians modelling reciprocal effects is developed. The model is restricted by eliminating from each model (Figures 7.2-4 and 7.2-5) any variable which was not statistically significant (see Figure 7.2-6). This resulted in the deletion of the variable population size.

The results of analysis of the combined model are presented in Figure 7.2-6 and Tables 7.2-6 and 7.2-7. Results indicate considerable support for the reciprocal effects predicted by the theoretical specification. Overall, the fit of the model is satisfactory ($\chi^2 = 6.59$; d.f = 5; P = 0.253); absolute value for the maximum normalized residual = 0.931 and the size of the maximum modification index = 3.74. The specification is supported by the data since first-order derivatives for the constrained parameters indicate that reciprocal effects, such as the ones modelled here are required to attain an acceptable fit.

The model explains 76.8 percent of the variance in change in specialists, 17.5 percent of the variance in change in general(family) practitioners and 23.3 percent of the variance in change in hospital beds, demonstrating that the combined model tested here explained a substantial portion of the variance in specialists but not general(family) practitioners.

Since the structure of the model is the same as the two models described above, the parameter estimates linking the predictor variables and the endogenous variables are almost the same. The path estimates shown in Figure 7.2-6 indicate that the structural relationships hypothesized, in general, are supported, with the

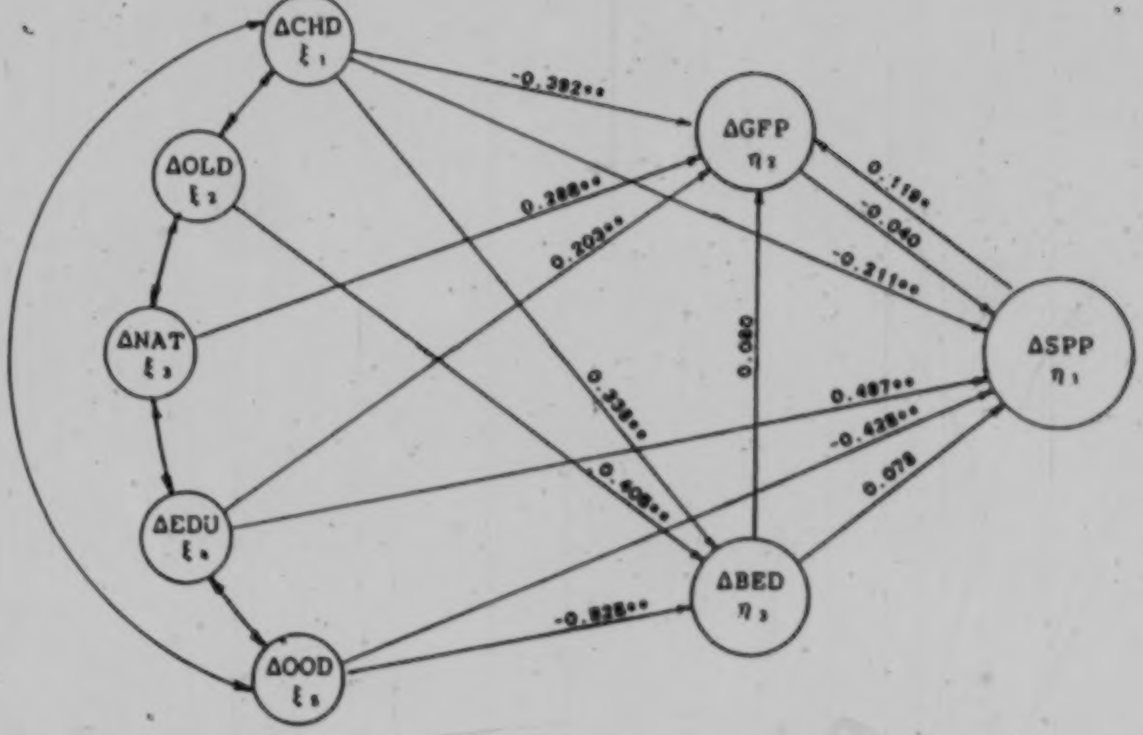

ΔCHD ξ_1
ΔOLD ξ_2
ΔNAT ξ_3
ΔEDU ξ_4
ΔOOD ξ_5
ΔGFP η_2
ΔBED η_3
ΔSPP η_1
-0.392**
0.288**
0.203**
0.119*
-0.040
-0.211**
0.080
0.338**
0.408**
0.487**
-0.428**
0.078
-0.828**

Figure 7.2-6 The Causal Diagram of the Change in General (Family) Practitioners and Specialists with Standardized Parameters as Estimated by LISREL

* Parameter is more than 1.5 times its standard error
** Parameter is more than twice its standard error

Table 7.2-6

Metric and Standardized[1] Structural Coefficients and Goodness-of-Fit Measures for the Model of Change in Physicians

	ΔSPP	ΔGFP	ΔBED	ΔCHD	ΔOLD	ΔNAT	ΔEDU	ΔOOD	R^2	PSI
ΔSPP	0.000* (0.000)	0.163 (0.119)	0.049 (0.078)	-6.728 (-0.211)	0.000* (0.000)	0.000* (0.000)	3.933 (0.497)	-1.551 (-0.425)	0.768	0.232
ΔGFP	-0.029 (-0.040)	0.000* (0.000)	0.037 (0.080)	-9.163 (-0.392)	0.000* (0.000)	1.310 (0.286)	1.180 (0.203)	0.000* (0.000)	0.175	0.825
ΔBED	0.000* (0.000)	0.000* (0.000)	0.000* (0.000)	17.063 (0.338)	7.537 (0.405)	0.000* (0.000)	0.000* (0.000)	-3.032 (-0.525)	0.233	0.767

χ^2=6.59 D.F.=5 P=0.253 GFI=0.991 AGFI=0.939 RMSR=10.548 Max NR=0.931 Max MI=3.74**

R^2 = Squared Multiple Correlations for Structural Equations
PSI = Covariances among the ζ Error Terms
χ^2 = CHI Square
D. F. = Degrees of Freedom
GFI = Goodness-of-Fit Index
AGFI = Adjusted Goodness-of-Fit Index
RMS = Root Mean Square Residual Correlation
Max NR = Maximum Normalized Residual
Max MI = Maximum Modification Index

[1] Standardized Coefficients in parentheses
* The parameter is constrained to zero.
** Warrants no further reduction of constraints in the Model is needed.

Table 7.2-7

Decomposition Effects of Endogenous and Exogenous Variables for the Model of Change in Physicians

Variables	ΔSPP			ΔGFP			ΔBED
	Direct	Indirect (via ΔGFP/ΔBED)	Total	Direct	Indirect (via ΔSPP/ΔBED)	Total	Direct (Total)
ΔSPP	0.000*	0.000*	0.000*	-0.040	0.000	-0.040	0.000*
ΔGFP	0.119	0.000*	0.119	0.000*	0.000*	0.000*	0.000*
ΔBED	0.078	0.010	0.088	0.080	-0.003	0.077	0.000*
ΔCHD	-0.211	-0.016	-0.227	-0.392	0.036	-0.356	0.338
ΔOLD	0.000*	0.035	0.035	0.000*	0.031	0.031	0.405
ΔNAT	0.000*	0.034	0.034	0.286	-0.001	0.285	0.000*
ΔEDU	0.497	0.022	0.519	0.203	-0.020	0.183	0.000*
ΔOOD	-0.425	-0.044	-0.469	0.000*	-0.023	-0.023	-0.525

* The parameters are constrained to zero.

following exceptions: effect of specialists on general(family) practitioners (β_{21}); and BED on specialists (β_{13}), and general(family) practitioners (β_{23}). The reciprocal effects are in opposite directions, with the effect of general(family) practitioners on specialists positive and statistically insignificant. Although the observation that the reciprocal effects (β_{12} and β_{21}) are of interest, the most important conclusion is that the data offer a stronger support for a causal link from general(family) practitioners and family physicians to specialists.

Table 7.2-7 summarizes the direct, indirect, and total causal effects of variables on the three endogenous variables. It shows that ΔOOD has the strongest indirect effect on change in specialists (ΔSPP) - mediated by hospital beds (ΔBED). These indirect influences reveal that an increase in economic prosperity does not correspond to an increase in hospital facilities and physicians' services. By contrast, the second equation (column 2 of Table 7.2-7) indicates that ΔEDU has the strongest indirect effect on change in general(family) practitioners (ΔGFP) - mediated by specialists. In this instance, an increase in the proportion of population who are university educated in an area creates a need for more specialized services in the area, which in turn, leads to an increase, although, not substantial, in the overall supply of physicians.

In general, these findings suggest that the causal effects of physician categories are not consistent with the theoretical perspectives suggested by earlier researchers. For example, Reskin and Campbell (1974) found negative zero-order correlations between several categories of physicians and the osteopaths suggesting that certain categories of physicians provide functional alternatives to certain other categories of physicians. If this is true, the positive relationships reported here are difficult to interpret. This, however, indicates that physicians recognize the importance of professional contacts and prefer to set up practice among other physicians. This would mean that policies aimed at making need-based physician recruitment by redistribution will not diffuse the overall supply of physicians if they prefer to practice among other specialties.

CHAPTER 8

SUMMARY AND CONCLUSIONS

It may be helpful to organize the discussion around three basic issues: (1) what major findings emerge from this research and what unique contribution does it make with regard to existing evidence on physician distribution; (2) what are the most important theoretical implications for scholars and researchers, and the most important policy implications for decision-makers; and (3) what are the suggestions for future study. These are taken up, in order, after a brief presentation of the thesis problem.

8.1 Overview of Thesis Problem

Analysis of the implications of large geographic differences in the distribution of physicians and access to medical care depends in large part on our understanding of the causes of physician distribution and change. In this thesis, a model derived from sociological human ecology is used to examine the consequences of population and environmental/technological factors on distribution and change in physicians.

The theoretical principle of 'ecological complex' (POET) as formulated by O. D. Duncan and Leo Schnore (Duncan, 1959, 1961, 1964; Duncan and Schnore, 1959; Schnore, 1958) provides a useful framework within which to examine the cause and effect relationships of the two sets of factors - population and environment/technology - on the organization (structure) of physician distribution. According to the POET scheme, in any society there is an ongoing interaction between the population, its social organization, its environment, and its technology. Despite the analytic potential of the 'ecological complex', empirical verification is surprisingly limited especially in the medical sociological literature. Also, much less attention, if any, has been given to the question of ecological change although it can be assumed that changes in organization result from changes in the independent variables such as environment.

The principal concern of this thesis is to explicate the theoretical and empirical dimensions of physician distribution (change) and its link with demographic, socio-economic, ecological, and environmental factors, as well as determining the extent of causal dependency. A second major concern is determining the causal links between groups of physicians - does one group of physicians influence the other group, or are there reciprocal effects between two groups?. Another way to describe this simultaneous interdependence is, do general practitioners and family physicians affect the distribution of specialists or do specialists affect the distribution of general practitioners and family physicians?.

Three hypotheses outlining our discussion of the links between physician distribution and the four sets of factors described can be briefly stated as:

1. demographic, socio-economic, and ecological factors affect environmental/technological factors which, in turn, affect the distribution of physicians;
2. changes in demographic and socio-economic factors affect changes in environmental/technological factors and these changes affect the change in physician distribution; and
3. physician groups have reciprocal effects on each other.

Sales Management Systems (SMS) data on all 'active civilian physicians' and census data on variables - population size, age composition, native population, education, owner-occupied dwellings, geographic proximity, and hospital beds - for areal units (census divisions) in 1971 (Time 1) and 1981 (Time 2) are used to test the hypotheses and estimate parameters concerning the influence of variables on physicians.

8.2 Summary of Approach and Major Findings

There is no doubt that the medical care available to the average citizen in Canada has improved considerably in recent decades. Implementation of Hospital Insurance and Medical Care Insurance have improved access to health services, but disparities remain between regions and between socio-economic classes. As some analysts believe, we still have a long way to go before Canada has a health care system which serves the needs of the entire population. The Canadian Health Survey (1978/79) provides considerable evidence for this argument. An analysis of the survey indicated that "people in lower income groups and with lower levels of education do not enjoy the same level of health as those Canadians of higher social and economic status" (Canada, 1981:114).

In Chapter 2, we have outlined the growth of the Canadian health care system, with special emphasis on the universal federal-provincial Hospital Insurance, Medical Care Act, and the federal-provincial Fiscal Arrangements and Established Programmes Financing Act. The chapter brought together various points to provide a brief account of the nature of the health care system and certain issues and problems which still exist.

The expanding supply of physicians has been one of the main developments in the health care system during the last decade. Longitudinal analysis of trends from 1971 to 1981, and the cross-sectional analysis of the provinces, supports this argument. The increase in national expenditures for medical services, which policy makers are now trying to restrain, is to some extent the result of an increase in the supply of physicians although hospitals and related institutions consume the largest portion of expenditure on health. One must also note that Canada has one of the highest hospital admission rates in the Western world, which, of course have greater implications for health care expenditures.

If health care costs are to be controlled without jeopardizing the quality of health care in Canada, public policy must deal with issues such as gross inequality in physician distribution.. As Hadley (1979:1060) noted, "if health planning is to become a meaningful component of the medical care system, then improvements in planning methods are needed." The subsequent chapters of the thesis have examined one part of the planning process, evaluating health professional distribution and change. The geographical distribution of physicians to ensure equality in access to the entire population is a significant issue that has not been given much attention by researchers, administrators or health planners in Canada. The intent of this thesis is to fill this gap.

We begin by briefly describing literature which identifies the factors that influence physician distribution. This is done in Chapter 3. This chapter illustrates some of the shortcomings, both theoretical and methodological, of current literature, and suggests the need for macrosociological structural analysis in addressing the problem of physician distribution within the framework of human ecology. The results of previous studies provide the rationale surrounding the set of predictor variables employed in the study. The empirical findings are then described and examined in the light of existing theories of physician distribution (Chapters 5 and 7).

The analysis involves use of two major techniques to ascertain to what extent the explanatory variables of demographic, socio-economic (including cultural), ecological, and environmental factors are determinants of physician distribution. The first of these techniques involves stepwise regression. The general model that is tested in the stepwise regression is as follows: population size, age-composition, education, native population, owner-occupied dwellings, and geographic proximity, all affect hospital beds and physician distribution. Because the nature of medical practice differs for interns, to general(family) practitioners to specialists, the general model is estimated separately, first predicting interns and residents, then predicting general(family) practitioners and finally predicting specialists.

The analysis of bivariate relationships is the broadest of all analyses reported in this study (Chapter 5). The primary interest here is to confirm the identification of the independent variables as indicators of physician distribution. Additionally, they are intended to reduce the total number of variables to a smaller and efficient set for use in multivariate and causal analyses. To briefly reiterate,

1. Population size, education, and owner-occupied dwellings are significant correlates of interns and residents at both Time 1 and Time 2. With one exception (i.e., population 65 years and older), the direction of effects of the independent variables remain quite consistent over time with population size, education, and hospital beds being positive correlates.
2. Population size and education are significant correlates of general practitioners and family physicians at Time 1, population under 5 years of age

and education are significant correlates at Time 2. Native population and geographic proximity change from negative to positive effects at Time 2.

3. While population size, women aged 15-44, education, and owner-occupied dwellings are significantly correlated with specialists at Time 1, these variables along with population under 5 years of age and geographic proximity, and hospital beds stand out as being significant correlates at Time 2.

The actual underlying pattern of dependence of physician distribution on predictor variables is revealed through multivariate analysis such as stepwise multiple regression. The stepwise multiple regression identified the independent variables which make a significant independent contribution to the explained variance of the physician distribution. Eight series of stepwise regressions are run using the seven variables: population size, population under 5 years of age, population 65 years and older, native population, education, owner-occupied dwellings, and geographic proximity.

From inspecting the regression coefficients, it would appear that population size is the most important predictor of intern and resident ratios at Time 1, followed by geographic proximity, population 65 years and older, and owner-occupied dwellings. These variables combine to account for approximately 57 percent of the variation in interns and residents. However, there are two considerable differences for interns and residents as compared with the result at Time 2. One is the substantial decrease in the predictive efficacy of the independent variables. For Time 2 data, they explain 13 percent of the variance rather than 59 percent at Time 1. Furthermore, the relative importance of the independent variables in predicting interns and residents has declined notably. Proportion native and proportion university educated, which contributed the least to the variance at Time 1, are the most powerful predictors at Time 2. Proportion owner-occupied dwellings also enters the regression equation at Time 2. The direction of relationships between the predictors and interns and residents, with one exception (i.e. owner-occupied dwellings), remains consistent over time.

For general(family) practitioners, the regression analysis produced similar results. For example, the same predictors, i.e. population size, population 65 years and older, owner-occupied dwellings, and geographic proximity have yielded more predictive potential at Time 1. Of these, only one predictor remained statistically significant at Time 2: geographic proximity. Surprisingly, population size of an area independently does not show any statistical significance in explaining general practitioners and family physicians at Time 2. The significant predictors in this case are population under 5 years of age, native population, and education. These explain nearly 12 percent of the variance, and reveal once again that predictors differ considerably over time. Also important to note is that the direction of the relationships between the predictors (population 65 years and older, owner-occupied dwellings, and geographic proximity) and general(family) practitioners have changed over time.

Regression results for specialists show that variation in specialists is explained by the same set of predictors identified for general(family) practitioners at Time 1. The variables population size, population 65 years and older, owner-occupied dwellings, and geographic proximity explain nearly 54 percent of the variance in specialists at Time 1. On the other hand, population size, population under 5 years of age, education, and owner occupied dwellings are found as the most powerful predictors at Time 2. They explain nearly 55 percent of the variance.

Aside from native population, none of the independent variables contribute significantly to the variance in hospital beds. However, the most unanticipated results are the positive coefficients for native population and geographic proximity. Some additional support for this result may be found in the regression results for general practitioners and family physicians at Time 2 (The two variables show negative effects on general(family) practitioners). In the Time 2 model, the significant predictors of hospital beds are population under 5 years of age, population 65 years and older, owner-occupied dwellings and geographic proximity. The predictive efficacy of the independent variables, in this case is almost tripled (18 percent against 7 percent) as compared to Time 1 model.

The regression results show a clear distinction between specialists and general(family) practitioners in terms of their predictors. The effects of hospital beds and owner-occupied dwellings are far greater for specialists than for general(family) practitioners. The results highlight the importance of socio-economic and ecological factors for understanding the dynamics of physician distribution. Areas closer to a metropolitan area receive more specialists, but fewer general(family) practitioners. On the other hand, the proportion of owner-occupied dwellings tends to vary inversely with physician ratios. This suggests that the decentralization of housing centres have a greater impact on the supply of physicians in larger cities - with higher proportions of owner occupied houses and corresponding lower levels of physician services in areas classified as 'outer ring' and lower proportions of owner occupied houses and higher levels of physician services in areas classified as 'inner core'.

A second technique employed is that of structural equation analysis (LISREL VI) which provides maximum-likelihood estimates of the unknown parameters in causal models containing exogenous and endogenous variables (Jöreskog and Sörbom, 1986). In the theoretical model, it is hypothesized that demographic, socio-economic, and ecological variables may exert direct and indirect effects - the latter mediated via hospital beds - on physicians. In turn, this mediating role of environment (hospital beds) might be expected to produce positive consequences for physician distribution. The proposed theoretical model is estimated separately for interns and residents, general(family) practitioners, and specialists for the two time points.

The results of the three structural analyses using Time 1 data suggest that although the overall fit of the model to the data is adequate in each case, there are notable differences in specific structural relationships for general(family) practitioners and specialists.

For general(family) practitioners, but not for specialists, native population has a significant positive effect. Thus, a higher proportion of natives is associated with a higher general(family) practitioner-population ratio. For specialists, the relationship is positive but not significant. Furthermore, hospital bed supply is associated significantly with specialists, but not with general(family) practitioners. These results once again suggest the improbability of developing a single model that can describe adequately the relationships between variables and physician ratios using pooled data for all types of physicians.

Clearly, physicians prefer to locate among their own professional groups. The interrelationships discovered among the three types of physicians emphasize the need for analyses of specific types of physician services to consider the presence/absence of alternative types of physicians. Thus, general(family) practitioners and specialists are found in teams, instead of singly. This, perhaps is the most significant piece of evidence to emerge from a combined model involving the two categories of physicians. These findings have arresting implications for policies which seek to redistribute physicians. We will come to this point later in the next section.

The findings of the Time 2 data must be considered more seriously than that of Time 1, mainly because of the incompleteness of the physician data at Time 1. It is established that structural models for the three physician groups differ substantially. Three major differences are evident in the causal structure for interns and residents, general(family) practitioners and specialists: population under 5 years of age affects interns and residents, whereas it does not affect the other two groups of physicians; native population and geographic proximity affect general(family) practitioners but not interns and residents and specialists; and owner-occupied dwellings affects general(family) practitioners and specialists whereas it does not affect interns and residents. Only one structural path (i.e., from education to physician ratios) is significant and positive for all the three groups. Age composition of the population (young and old age groups) exerts a significant negative effect on all the three categories of physicians although the two age groups have positive effects on hospital beds.

The evidence suggests that, in general, areas rich in hospital beds do not necessarily have a large number of physicians. For example, the number of hospital beds has almost no effect on interns and residents and general(family) practitioners, although it has a significant positive effect on specialists. Professional intercourse seems more important to these physicians than are hospital facilities per se. This also implies the importance of considering personal attributes such as age and sex of physicians which may have consequences for the location decision.

From inspecting the reciprocal effects, it would appear that interns and residents, and general(family) practitioners affect specialists and are affected by the two groups. Also, interns and residents, and general(family) practitioners have reciprocal effects on each other. The findings suggest that interns and residents, not general(family) practitioners, are more associated with specialists.

The stronger effect of interns and residents on specialists as compared to general(family) practitioners is easy to explain. It is so because interns and residents with high educational and occupational aspirations must locate in a medical educational setting where facilities for specialty training are available. This, together with the changing role of family physicians to provide health care outside the hospital tend to create a situation where interns and residents place considerable significance and importance on their relationship with specialists. One must be cautious, however, in interpreting this result because the ecological correlations do not necessarily reflect individual correlations. Nonetheless, they are highly suggestive and imply that increase or decrease in the supply of one group of physicians can produce increase or decrease in the supply of other group(s) of physicians.

While our results suggest that general(family) practitioners and specialists have reciprocal effects on each other, there is some evidence that the effect of general(family) practitioners family physicians is both stronger and positive as opposed to the effect of specialists on general practitioners and family physicians. McWhinney (1972:233) has argued that in urban and metropolitan areas, primary care is also provided by specialists, whereas in small towns and rural areas, family physicians often provide all services including surgery. In few areas, however, he noted, "the provision of primary care by specialists led to the eclipse of the general practitioner." We are convinced that we have empirically identified this phenomenon, the so-called "substitution effect".

A next important step is to model change using residualized change scores. This is done in Chapter 7. The proposed theoretical model suggests that a change in demographic and socio-economic factors effects change in hospital bed supply, which, in turn, effects a change in physician supply.

The variables used in static models (except, geographic proximity) are used in bivariate, multivariate, and structural analyses of change. The regressions provide a replication to assess the predictive ability of variables, and they permit some interesting comparisons with the Time 1 and Time 2 results of our static models.

The regression results suggest that an increase in the proportion of educated persons and the proportion of natives are the two most important factors closely associated with the change in the supply of general(family) practitioners. An increase in the proportion of children under 5 years of age, on the other hand does not contribute to an increase in the supply of general(family) practitioners indicating that the supply of physicians is not in accordance with the demand for their services. These findings are consistent with those reported earlier in static models. On the whole, the effect of change in socio-economic factors is quite strong in the case of specialists. After controlling for demographic factors, areas that have experienced an increase in the proportion of highly educated persons also experienced an increase in specialists.

Such findings are further evidenced in the structural equation analyses. We come up with the same three variables - population under 5 years of age, native population and education of the population - that contribute to a change in the supply of general(family) practitioners. The effect of population under 5 years of age is the strongest effect in the model. This would mean that a change in the proportion of population under 5 is also followed by a change in the supply of general(family) practitioners. However, the evidence indicates a movement of general(family) practitioners away from areas experiencing an increase in the proportion of young population. Socio-economic factors rather than demographic are more important determinants of change in specialists. Of the two socio-economic variables in the model, owner-occupied dwellings has a much greater impact on specialists than education. It influences physician distribution indirectly through hospital beds. Both the models have shown that change in hospital bed supply has a significant effect on change in physician supply.

Population size is the least influential factor in determining the change in specialists. This is not too surprising, given that none of the demographic factors (except, perhaps, population under 5 years of age) are found to be statistically significant. These results also confirm cross-sectional findings. Proportion of owner-occupied dwellings merits inclusion in models of change in specialists but is not associated with change in general practitioners and family physicians.

A final comment concerns the interdependencies among physician groups. Consistent with findings from cross-sectional data, our trend data indicate that an increase in the supply of general(family) practitioners corresponds to an increase in the supply of specialists but an increase in the supply of specialists does not correspond to an increase in the supply of general(family) practitioners.

8.3 Implications of Thesis and Broader Relevance

This study has clear implications for sociological human ecology and for health planning. The results of the analyses provide initial support for the conceptual framework, the so-called "ecological complex". Our assessment of the impact of demographic, socio-economic, and ecological variables on geographic differences in physician distribution, including their indirect effects via hospital facilities, finds support for the human ecology framework which maintains that organization (O), arises as the result of interaction between population (P), environment (E), and technology (T). At the same time, hospital beds exert an impressive (though not always) independent direct effect on the pattern of physician supply. Thus, the findings are supportive of the view that technology and/or the availability of environmental resources have important implications for the organization of a population or subgroup of a population.

The findings neither simply confirm nor deny the mediating role played by hospital beds. While this factor acts as an important contributor to the distribution of certain categories of physicians, the fact that it does not mediate the impact of antecedent variables on physician ratios means that it does not occupy an exclusive path to altering geographical (im)balances in physician ratios. High status areas (e.g., percentage university educated) attract physicians regardless of whether or not they have good hospital facilities. It is possible that other forms of technology (e.g., specialized equipment) may have quite different implications for physicians. While different theorists and researchers allude to these possibilities, they do not explicitly include them in their research either because of the lack of such information or because there is little in the human ecological literature to allow one to include these concepts in a single framework.

In the human ecological literature, there is little effort to theoretically circumscribe the concept of environment. To the ecologist, environment includes all external elements to which a population, and its institutions/service delivery systems are responsive. Medicine is one such service system which is very much dependent upon a complex of supportive services, institutional facilities including high-tech equipment and health personnel. Given this perspective, the availability of hospital beds and specialized medical equipment are difficult to separate conceptually although they may refer to two different concepts in the POET scheme. This analysis points to the need for ecological theorists to substantially clarify and delineate the POET concepts so as to form a useful framework for studying physician distribution.

A second implication from this study points to the need to focus on ecological change. It may be, as Hawley suggests, that ecological changes "that result in an increase in productivity of key functions stimulate system growth, or cumulative change" (Micklin, 1984:66). The process delineated in this study has been one in which the diminution of socio-economic inequality has been necessary to reduce disparities in the supply of specialists. This is particulary important when trying to improve the mortality levels among minorities. Since specialists are fewer where owner-occupied dwellings are more, the importance of freezing specialists' growth in inner city areas and allocating their services to both inner and outer areas in proportion to respective populations cannot be over-emphasized. These are important findings and are clear evidence of a socio-economic response to organizational structure of medical services in general, and physicians in particular.

Finally, this study reinforces our belief that physician groups are interdependent, they have reciprocal causal effects on each other. If the models are convincing, they would seem to have important implications for studies which are concerned with only the recursive effects, rather than the effects of two groups of physicians on each other. In short, our findings suggest that reciprocal causal effects between different types of physicians must be explicitly incorporated into both theory and research concerned with the issue of distribution of physicians.

In summary, although the lack of physician supply may be acute in rural areas, the evidence from this study suggests that the extent and intensity of (specialists) shortages is greater in (peripheral) residential areas. Perhaps the most surprising of the findings is the inverse association between the supply of physicians and the two 'high medical risk' groups: percent population under 5 and percent population 65 years and over. This emphasizes the regressive nature of physician supply in relation to demand. Another major finding is that physicians tend to avoid areas where a large proportion of the population is 'native'. This may mean that people in real need of care are denied it due to a deficiency in service provision. The opportunities for obtaining good-quality medical care can be very few for ethnic minorities and this must inevitably reduce utilization. This, to a large extent, explains the ethnic differentials in health in this country; the health status and life expectancy of ethnic minorities (natives) being almost always inferior to those of the majority of the population.

With these findings, what then of government attempts to influence physician location and thereby improve the distribution? Increasing the total supply of physicians has often been viewed as a means of improving the distribution. The underlying assumption is that market saturation would eventually cause physicians to avoid physician-rich areas. The evidence, however, suggests that such policies have been only partially successful. In Canada, as we noted earlier, although the absolute number of physicians in most underserviced areas has increased since the mid-1960, overserviced areas too have improved their relative positions, creating a situation of oversupply. In other words, the increase in physician supply has not improved disparity since the increase is confined mainly to the cities.

Ontario, however, has had some success with a system of cash bonuses and guaranteed incomes in attracting physicians to underserviced areas (Rubin, 1981). An earlier study by Bass and Copeman (1975), however, suggested that financial incentives have only small effects on physicians' choices of location. Their study showed that of the 217 medical students who accepted bursaries during the first years of the Ontario Programme for Underdoctored Areas, only 53% honoured their contracts, the remaining 47% committing themselves to repaying their bursaries.

There are several factors affecting distribution (e.g., personal preferences for city living) that are difficult or impossible to change. Since only a limited number of factors can be modified by deliberate policies, health manpower planners should concentrate on them to entice physicians to establish and maintain their practice in 'underserviced areas'. If we accept that health serves as a barometer of the social and economic conditions in which people live, from a policy point of view, diminution of socio-economic differentials between areas may be one of the routes through which equality in care is achieved. The results to date suggests that neither money (e.g., tax free grants) nor legislation of incentive programmes are enough to recruit and retain physicians in underserviced areas (Gilmore, 1985). As Schoenman and Sloan (1986) have noted, given monetary equilibrium, geographic imbalances with respect to physician supply will remain because there are differences in amenities (see also Kopetsky, 1988).

Rather surprisingly, the younger and older age groups turned out to have little or no effect on physicians. In some instances, the effect is negative. This could be summed up as the inverse care law: that the supply of physician services tends to vary inversely with the need of the population served (Hart, 1971: 412)'. In recent years, however, there is much concern over the impact of demographic changes on the costs of health care. It has been argued that changes in size and age composition of the population increase the demand for health services and hence the relative burden of health care costs. However, the significant negative effect of elderly population on change in the supply of physicians in the presence of rather steadily rising quality of services is reason enough to be skeptical about such concern. The argument here is that demographic changes can be expected to have a smaller impact on the cost of health care in the long run and whatever occurs in a decade or so may primarily be due to the result of changes in the quality of services provided and probably not the result of an ageing population. In other words, the ageing of the population does not appear to portend a 'crisis' in health care cost as some analysts have been suspecting for a long time. This argument is consistent with the recent analysis of Roos and her colleagues (1987:342) in which these authors found that 'the elderly' are not necessarily high users of health care services, and their rates of referral to specialist is even lower than the younger age groups. In their words: "'the looming crisis' in health care delivery, which is expected from the ageing of our population, should be rethought" (Roos et al. 1987:342). As Denton and his colleagues (1986:75) have noted, to a considerable extent the changes in government expenditures result from a very large increase in social security costs.

A final comment may be in order with regard to the general problem of physician distribution. A major accomplishment of this study is the specification of an empirical model that corresponds closely to the theory of 'substitution effect' - a theory that emphasizes that one group of physicians affects another group simultaneously and reciprocally. We found strong evidence of dependency among categories of physicians. For example, areas that have experienced an increase in general(family) practitioners have also experienced an increase in specialists. But areas which have experienced an increase in specialists have not experienced an increase in general(family) practitioners. Given this interdependency, it seems unlikely that general(family) practitioners may be expected to supplement or substitute specialists. This implies that increasing the supply of certain groups of physicians may lead to "over-doctoring" as physicians prefer to locate among other physicians. Obviously, if general(family) prctitioners do attract more specialists, the difficulties of realizing a more even distribution would be acute especially if the increase is confined to large urban centres. Physicians will be reluctant to practice in rural areas because they feel isolated from collegial network, complex diagnostic and treatment aids, and the ancillary assistance available in more urbanized areas (Mechanic, 1972:287). In view of this, what can be achieved in the future in terms of improving distribution and reducing inequalities in health, possibly by assigning physicians in teams rather than singly.

To repeat an argument made earlier, any programme designed to redistribute physicians that is based on increasing the supply will not necessarily be successful. This is because the distribution of physicians is a part of a macro socio-economic process and physicians in general tend to favour those communities that best suit them. If this conclusion is accepted, then programmes directed to modifying the distribution of physicians must focus on the causes underlying the distribution ... i.e., recognize the importance of maintaining socio-economic resources and hospital (educational) facilities in attracting new physicians to underserved areas and in retaining them. It is important, therefore that policy makers reassess their policies before the substantial cost accompanying the growing supply of physicians and distribution problems are aggravated further.

The evidence presented in this study suggests that disparities in the supply of physicians relative to demand for services appears to be related to the locational attitudes and preferences of physicians and to the properties of the locale. Although the present study is limited to the latter aspect, it is not always easy to distinguish the impacts of individual preferences or attitudes from those of structural constraints (Joseph and Phillips, 1984). Therefore, attempts to manipulate the physician location system based only upon individual aspects of physician preference (e.g., financial incentive schemes) or on structural constraints (e.g., hospital beds) have met with only partial success. Experience to date suggests that, in the absence of governmental control over physicians' choices of practice location, measures to improve distribution may depend on a wide spectrum approach to the problem, by simultaneously addressing perhaps financial incentive programmes and infrastructure development.

8.4 Suggestions for Further Research

Despite the voluminous literature on physician distribution, there still remain many gaps and unanswered questions. Future research needs on physician distribution would appear to be three-fold. In the first place, considerable work needs to be devoted to conceptualizing and operationalizing the POET concepts, in particular, *environment* for use as a framework for physician distribution studies.

Secondly, having operationalized the concepts, more attention should be focused on the relationship between environment and organization of (physician)population. For example, while the data in the present study have supported the theoretical importance of hospital facilities in the determination of physician distribution, they have also under-scored the importance of physicians in explaining hospital facilities. In fact, an increase in the supply of specialists could predict an increase in the number of short-term general hospital beds (see Anderson, 1977:680). Anderson claims that admission rates and average length of stay would also increase due to this growth in the supply of hospital beds and ultimately the number of deaths due to infective and parasitic diseases will decrease. Research needs to be performed for further exploration of the ramifications of physicians on the availabilty of hospital facilities. Not to be overlooked in future research would be the need to include hospital facilities, particularly hospital beds and standard laboratory facilities and specialized equipment as they can reduce the disadvantages of rural communities by attracting more physicians there.

Third, we cannot rule out any of the perspectives on physician distribution and personal characteristics reviewed in the third chapter of this thesis. Additional valuable information may be obtained in further studies if one explores such complex variables as physician characteristics, and personal life style preferences. For the purpose of understanding and predicting attitudes and behaviour of physicians, micro-data must be collected and analyzed. The adverse effects of manpower planning with inaccurate data are now well known. Availability of accurate medical manpower information is an increasingly serious problem, and health manpower planning is currently based on erroneous and nonexistent data (Moore, 1982). There is little doubt that physician distribution has macro-aims and programme planning and implications depend in large part on ecological research. However, this author believes that as long as the investigators confine their attention to aggregate data in their analyses, important trends in stability and causal influences may be obscured. Answers to these issues would help in the formulation of more effective policies and programmes to help improve physician distribution and also provide a better understanding of the structure and form of institutions/institutionalized services in general and the dynamics of ecological change.

ENDNOTES

[1] *Population* refers to any collectivity of persons functioning as a unit.

Organization refers to the social structure that enables the population to sustain itself in an environment.

Environment refers to all phenomena external to the population including the social systems.

Technology refers to the artifacts, tools, and techniques used by the population to influence the environment. (see Palen, 1981. Pp.18-19)

[2] The Honourable John Munro's (Minister of National Health and Welfare) speech to the Canadian Education Seminar for Hospital Administration, November 30, 1971, Ottawa, Ontario, Canada.

[3] Data are for 1981, published by Indian and Northern Affairs Canada. Population Projections of Registered Indians, 1982 to 1996.

[4] We have not included the nine variables in our structural equation models because the major purpose of this thesis is to document spatial patterns and trends in physician distribution in the context of socio-demographic and environmental change and because an excessive number of independent variables relative to the number of observations (ranges from 59 to 217) distorts the estimates of the coefficients. Another argument for not including them is that they are exogenous rather than endogenous variables in the physician distribution models. Consequently it is statistically problematic simply to include them in the structural equation models.

[5] Selection criteria are specified as follows: the minimum F-to-enter and tolerance levels are set at 1.0 and 0.5 respectively. The former assures that the standardized partial regression coefficient of a variable would make a substantial additive contribution and the latter assures that a selected variable is not a linear

combination of the other selected variables (see Nie et al. 1975:346)

[4] The concept of need is loosely defined here, and not expressed in terms of the mortality and morbidity rates (see Joseph and Phillips (1984)).

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APPENDIX A: COVARIANCE MATRICES AND MEASUREMENT MODEL PARAMETERS FOR MODELS AT TIME 1

Table A-1
Covariance Matrix for Interns and Residents Model at Time 1

	IRP	BED	POP	CHD	OLD	NAT	EDU	OOD	GEP
IRP	8262.115								
BED	335.445	2144.594							
POP	264.176	-0.300	17.946						
CHD	-10.062	-3.160	-0.727	0.786					
OLD	-0.784	8.740	3.125	-1.378	12.856				
NAT	-20.744	-11.251	-0.970	0.425	0.710	5.258			
EDU	98.042	17.834	6.645	0.078	1.335	-0.512	10.073		
OOD	-294.265	-75.489	-22.593	1.472	7.883	7.253	-16.146	113.211	
GEP	-719.194	-1166.755	144.534	-13.564	-24.708	5.199	-3.922	-211.914	19897.776

Table A-2

Residuals, S-Σ for the Model of Figure 6.3-1 and the Data of Table A-1

	IRP	BED	POP	CHD	OLD	NAT	EDU	OOD	GEP
IRP	-0.043								
BED	-0.473	0.000							
POP	-0.027	-0.519	-0.000						
CHD	-0.002	0.003	-0.002	0.000					
OLD	0.005	0.032	0.004	0.000	-0.000				
NAT	-0.007	0.003	-0.003	-0.000	-0.000	0.000			
EDU	0.004	0.043	0.001	0.000	-0.000	0.000	-0.000		
OOD	-0.012	-0.045	-0.009	-0.000	0.001	0.000	0.001	-0.001	
GEP	-0.017	0.035	-0.020	0.000	0.001	-0.000	0.002	-0.001	0.002

Table A-3

First-order Derivatives of B (BETA) and Γ (GAMMA) for the Interns and Residents Model at Time 1

	BETA	
	IRP	BED
IRP	0.000	-0.000
BED	0.135	0.000

				GAMMA			
	POP	CHD	OLD	NAT	EDU	OOD	GEP
IRP	-0.000	0.000	-0.000	0.000	-0.000	0.000	-0.000
BED	0.006	0.000	0.000	-0.000	-0.000	-0.000	-0.000

Table A-4

Loadings for Indicators of Exogenous Constructs (Λ_x) and Error Terms of Exogenous Indicators (Θ_δ) and Loadings for Indicators of Endogenous Constructs (Λ_y) and Error Terms of Endogenous Indicators (Θ_ϵ) for the Interns and Residents Model at Time 1

Variables	Λ_x (Lambda sub x)	Θ_δ (Theta sub delta)*
POP	4.019	1.795
CHD	0.841	0.079
OLD	3.402	1.286
NAT	2.114	0.789
EDU	2.926	1.511
OOD	10.095	11.321
GEP	130.021	2984.666
	Λ_y (Lambda sub y)	Θ_ϵ (Theta sub epsilon)*
IRP	79.135	2065.529
BED	41.421	428.919

* Error variances are fixed.
Note: The loadings are standardized.

Table A-5

Covariance Matrix for General (Family) Practitioners Model at Time 1

	GFP	BED	POP	CHD	OLD	NAT	EDU	OOD	GEP
GFP	4572.184								
BED	179.067	2123.219							
POP	100.231	0.881	5.734						
CHD	-6.275	-1.731	-0.331	2.424					
OLD	9.821	9.738	0.347	-2.578	9.20				
NAT	-4.967	44.648	-0.941	3.976	-2.169	31.036			
EDU	40.535	10.688	2.710	-0.054	-0.155	-0.372	6.899		
OOD	-90.437	-34.521	-10.753	0.943	11.973	1.358	-11.626	102.247	
GEP	-373.365	502.118	11.620	123.285	-131.040	274.857	-19.493	-20.808	24547.131

Table A-6

Residuals, $S-\Sigma$ for the Model of Figure 6.3-2 and the Data of Table A-5

	GFP	BED	POP	CHD	OLD	NAT	EDU	OOD	GEP
GFP	-0.064								
BED	-0.608	0.000							
POP	-0.055	-0.765	0.002						
CHD	-0.028	0.038	-0.015	0.000					
OLD	-0.008	0.064	0.006	-0.001	-0.000				
NAT	0.033	-0.033	0.035	-0.001	-0.002	0.002			
EDU	0.235	0.029	-0.031	0.012	0.017	-0.012	-0.001		
OOD	0.013	-0.079	-0.006	0.001	0.004	0.002	-0.021	-0.004	
GEP	0.022	0.017	0.013	-0.000	-0.001	-0.000	0.007	0.001	-0.000

Table A-7

First-order Derivatives of B (BETA) and Γ (GAMMA) for the General (Family) Practitioners Model at Time 1

	BETA	
	GFP	BED
GFP	-0.000	0.000
BED	0.068	0.000

				GAMMA			
	POP	CHD	OLD	NAT	EDU	OOD	GEP
GFP	-0.000	-0.000	-0.000	0.000	-0.001	0.000	0.000
BED	0.003	-0.000	0.000	0.000	-0.000	-0.000	0.000

Table A-8

Loadings for Indicators of Exogenous Constructs (Λ_x) and Error Terms of Exogenous Indicators (Θ_δ) and Loadings for Indicators of Endogenous Constructs (Λ_y) and Error Terms of Endogenous Indicators (Θ_ϵ) for the General (Family) Practitioners Model at Time 1

Variables	Λ_x (Lambda sub x)	Θ_δ (Theta sub delta)*
POP	2.272	0.573
CHD	1.477	0.242
OLD	2.879	0.921
NAT	5.136	4.655
EDU	2.422	1.035
OOD	9.595	10.225
GEP	144.448	3682.070
	Λ_y (Lambda sub y)	Θ_ϵ (Theta sub epsilon)*
GFP	60.717	914.437
BED	41.213	424.644

* Error variances are fixed.
Note: The loadings are standardized.

Table A-9

Covariance Matrix for the Specialists and Combined Model (Excluding Interns and Residents) at Time 1

	SPP	GFP	BED	POP	CHD	OLD	NAT	EDU	OOD	GEP
SPP	8588.984									
GFP	6284.297	5190.086								
BED	243.398	137.206	1715.493							
POP	167.603	114.083	1.327	6.488						
CHD	-12.688	-5.855	2.629	-0.360	2.081					
OLD	-4.339	10.658	1.948	0.558	-2.312	9.215				
NAT	-30.492	-1.816	34.466	-0.705	2.250	-1.551	14.842			
EDU	83.011	11.544	2.931	0.071	0.020	0.038	7.366	7.366		
OOD	-287.119	-92.729	-46.336	-11.246	1.086	11.145	-0.171	-11.142	101.073	
GEP	-1348.355	-428.379	361.598	16.449	119.479	-139.654	210.883	-22.792	-32.295	25982.010

Table A-10

Residuals, S-Σ for the Model of Figure 6.3-3 and the Data of Table A-9

	SPP	BED	POP	CHD	OLD	NAT	EDU	OOD	GEP
SPP	-0.072								
BED	-0.589	0.002							
POP	-0.048	-0.741	-0.002						
CHD	-0.017	0.022	0.007	-0.001					
OLD	-0.001	0.052	0.013	-0.002	-0.003				
NAT	0.289	-0.045	-0.033	0.008	0.022	0.002			
EDU	0.008	0.043	0.003	0.000	-0.000	-0.006	-0.000		
OOD	-0.006	-0.067	-0.014	0.002	0.003	-0.018	0.001	-0.003	
GEP	-0.009	0.027	0.000	-0.002	-0.002	0.017	0.000	0.002	-0.001

Table A-11

First-order Derivatives of B (BETA) and Γ (GAMMA) for Specialists Model at Time 1

	BETA		GAMMA						
	SPP	BED	POP	CHD	OLD	NAT	EDU	OOD	GEP
SPP	0.000	0.000	0.000	0.000	0.000	-0.002	0.000	-0.000	0.000
BED	0.110	-0.000	0.003	0.000	0.000	-0.000	-0.000	-0.000	-0.000

Table A-12

Loadings for Indicators of Exogenous Constructs (Λ_x) and Error Terms of Exogenous Indicators (Θ_δ) and Loadings for Indicators of Endogenous Constructs (Λ_y) and Error Terms of Endogenous Indicators (Θ_ϵ) for the Specialists Model at Time 1

Variables	Λ_x (Lambda sub x)	Θ_δ (Theta sub delta)*
POP	2.417	0.649
CHD	1.369	0.208
OLD	2.880	0.921
NAT	3.551	2.226
EDU	2.502	1.105
OOD	9.539	10.107
GEP	148.617	3897.301

	Λ_y (Lambda sub y)	Θ_ϵ (Theta sub epsilon)*
SPP	83.283	1717.797
BED	37.042	343.099

* Error variances are fixed.

Note: The loadings are standardized.

Table A-13

Residuals, S-Σ for the Model of Figure 6.3-4 and the Data of Table A-9

	SPP	GFP	BED	POP	CHD	OLD	NAT	OOD	GEP
SPP	0.066								
GFP	0.042	0.000							
BED	0.360	0.467	-0.000						
POP	-0.012	0.007	-0.172	0.001					
CHD	0.148	0.065	0.136	-0.039	0.008				
OLD	0.043	0.006	0.630	-0.006	0.019	0.003			
NAT	-0.013	0.002	-0.072	0.005	0.006	-0.027	0.001		
OOD	-0.022	-0.001	-0.154	0.000	0.011	0.008	0.000	-0.005	
GEP	-0.626	-0.747	-0.047	0.149	-0.028	-0.056	0.035	0.073	-0.003

Table A-14

First-order Derivatives of B (BETA) and Γ (GAMMA) for the Combined Model (Excluding Interns and Residents) at Time 1

		BETA				GAMMA			
	SPP	GFP	BED	POP	CHD	OLD	NAT	OOD	GEP
SPP	0.000	0.000	0.000	-0.000	-0.001	-0.000	-0.000	-0.000	-0.000
GFP	-0.016	0.000	-0.044	0.000	0.000	0.000	-0.000	0.000	0.202
BED	-0.065	-0.065	-0.000	0.000	0.000	-0.003	-0.000	-0.000	0.010

Note: The loadings are standardized.

Table A-15

Loadings for Indicators of Exogenous Constructs (Λ_x) and Error Terms of Exogenous Indicators (Θ_δ) and Loadings for Indicators of Endogenous Constructs (Λ_y) and Error Terms of Endogenous Indicators (Θ_ϵ) for the Combined Model (Excluding Interns and Residents) at Time 1

Variables	Λ_x (Lambda sub x)	Θ_δ (Theta sub delta)*
POP	2.416	0.649
CHD	1.368	0.208
OLD	2.879	0.921
NAT	3.552	2.226
OOD	9.540	10.107
GEP	148.635	3897.301
	Λ_y (Lambda sub y)	Θ_ϵ (Theta sub epsilon)*
SPP	92.359	0.000
GFP	72.042	0.000
BED	37.046	343.099

* Error variances are fixed.
Note: The loadings are standardized.

APPENDIX B: COVARIANCE MATRICES AND MEASUREMENT MODEL PARAMETERS FOR MODELS AT TIME 2

Table B-1

Covariance Matrix for Interns and Residents Model at Time 2

	IRP	BED	POP	CHD	OLD	NAT	EDU	OOD	GEP
IRP	1317.565								
BED	249.840	3892.101							
POP	21.418	6.449	7.941						
CHD	-4.612	-0.496	-0.838	1.126					
OLD	-13.324	16.353	-0.674	-1.493	8.969				
NAT	-8.461	-10.011	-0.510	0.666	-0.851	7.489			
EDU	50.376	-4.638	6.179	-0.937	-2.305	-0.019	25.027		
OOD	-80.224	-213.388	-12.753	1.646	7.108	1.923	-14.293	99.112	
GEP	-432.157	-23.308	-81.208	42.297	-129.941	162.731	-108.158	174.366	20836.694

Table B-2

Residuals, S-Σ for the Model of Figure 6.4-1 and the Data of Table B-1

	IRP	BED	POP	CHD	OLD	NAT	EDU	OOD	GEP
IRP	0.006								
BED	0.044	-0.000							
POP	0.168	0.002	0.000						
CHD	0.008	0.032	0.003	-0.001					
OLD	0.002	0.028	0.004	-0.002	-0.002				
NAT	-0.108	-0.933	-0.014	0.026	0.048	-0.000			
EDU	0.009	0.027	-0.006	-0.001	-0.002	-0.004	0.001		
OOD	0.013	-0.001	0.001	0.003	0.002	-0.074	0.002	-0.000	
GEP	0.015	0.096	0.003	-0.003	-0.005	0.018	-0.000	0.008	-0.003

Table B-3

First-order Derivatives of B (BETA) and Γ (GAMMA) for the Interns and Residents Model at Time 2

	BETA	
	IRP	BED
IRP	0.000	-0.000
BED	-0.003	-0.000

	GAMMA						
	POP	CHD	OLD	NAT	EDU	OOD	GEP
IRP	-0.001	-0.000	-0.000	0.000	0.000	-0.000	0.000
BED	0.000	0.000	0.000	0.003	-0.000	-0.000	0.000

Table B-4

Loadings for Indicators of Exogenous Constructs (Λ_x) and Error Terms of Exogenous Indicators (Θ_δ) and Loadings for Indicators of Endogenous Constructs (Λ_y) and Error Terms of Endogenous Indicators (Θ_ϵ) for the Interns and Residents Model at Time 2

Variables	Λ_x (Lambda sub x)	Θ_δ (Theta sub delta)*
POP	2.673	0.794
CHD	1.007	0.113
OLD	2.841	0.897
NAT	2.523	1.123
EDU	4.612	3.754
OOD	9.445	9.911
GEP	133.107	3125.504
	Λ_y (Lambda sub y)	Θ_ϵ (Theta sub epsilon)*
IRP	32.453	263.513
BED	55.802	778.420

* Error variances are fixed.
Note: The loadings are standardized.

Table B-5

Covariance Matrix for General (Family) Practitioners Model at Time 2

	GFP	BED	POP	CHD	OLD	NAT	EDU	OOD	GEP
GFP	762.389								
BED	140.945	3618.631							
POP	8.294	6.610	6.320						
CHD	-6.218	3.466	-0.627	1.408					
OLD	8.205	14.845	-0.913	-1.844	10.838				
NAT	15.498	28.165	-1.053	2.549	-1.200	35.940			
EDU	25.538	2.495	5.074	-0.664	-2.738	-1.185	21.318		
OOD	-31.275	-189.332	-11.657	0.678	9.414	0.447	-15.442	102.027	
GEP	416.092	367.176	-72.387	58.400	-125.133	297.445	-95.462	234.953	21010.009

Table B-6

Residuals, S-Σ for the Model of Figure 6.4-2 and the Data of Table B-5

	GFP	BED	POP	CHD	OLD	NAT	EDU	OOD	GEP
GFP	-0.002								
BED	-0.052	0.000							
POP	-0.118	0.004	0.000						
CHD	-0.001	0.030	-0.003	-0.001					
OLD	0.003	0.022	0.002	-0.002	-0.002				
NAT	-0.015	-0.466	-0.003	0.012	0.024	-0.000			
EDU	-0.009	0.007	0.005	0.000	-0.000	-0.002	-0.001		
OOD	-0.011	-0.009	-0.001	0.002	0.002	-0.034	0.001	-0.001	
GEP	0.001	0.036	0.006	-0.002	-0.002	0.014	-0.000	0.003	-0.002

Table B-7

First-order Derivatives of B (BETA) and Γ (GAMMA) for the General (Family) Practitioners Model at Time 2

	BETA	
	GFP	BED
GFP	-0.000	-0.000
BED	0.002	-0.000

				GAMMA			
	POP	CHD	OLD	NAT	EDU	OOD	GEP
GFP	0.001	0.000	0.000	0.000	-0.000	-0.000	0.000
BED	0.000	0.000	-0.000	0.003	-0.000	0.000	-0.000

Table B-8

Loadings for Indicators of Exogenous Constructs (Λ_x) and Error Terms of Exogenous Indicators (Θ_δ) and Loadings for Indicators of Endogenous Constructs (Λ_y) and Error Terms of Endogenous Indicators (Θ_ϵ) for the General (Family) Practitioners Model at Time 2

Variables	Λ_x (Lambda sub x)	Θ_δ (Theta sub delta)*
POP	2.385	0.632
CHD	1.126	0.141
OLD	3.123	1.084
NAT	5.527	5.391
EDU	4.257	3.198
OOD	9.583	10.203
GEP	133.647	3151.501

	Λ_y (Lambda sub y)	Θ_ϵ (Theta sub epsilon)*
GFP	24.700	152.478
BED	53.804	723.726

* Error variances are fixed.
Note: The loadings are standardized.

Table B-9

Covariance Matrix for Specialists Model at Time 2

	GFP	BED	POP	CHD	OLD	NAT	EDU	OOD	GEP
GFP	1493.664								
BED	433.377	3769.843							
POP	50.352	5.542	7.124						
CHD	-14.181	1.896	-0.746	1.313					
OLD	-5.577	10.112	-0.759	-1.892	9.681				
NAT	-35.716	23.797	-1.028	2.803	-2.635	36.238			
EDU	106.083	-8.285	5.438	-0.848	-2.297	-0.828	22.582		
OOD	-215.675	-195.814	-12.032	1.321	7.619	-0.616	-13.574	100.394	
GEP	-1349.107	395.177	-79.957	65.199	-154.183	350.165	-100.037	222.348	22535.091

Table B-10

Residuals, S-Σ, for the Model of Figure 6.4-3 and the Data of Table B-9

	GFP	BED	POP	CHD	OLD	NAT	EDU	OOD	GEP
GFP	0.005								
BED	0.024	0.002							
POP	0.003	0.007	0.000						
CHD	0.030	0.053	0.000	-0.000					
OLD	0.181	0.029	-0.003	0.004	-0.003				
NAT	-0.070	-0.628	-0.007	0.017	0.037	-0.001			
EDU	0.011	0.019	-0.000	-0.005	-0.034	-0.002	-0.003		
OOD	-0.013	-0.018	0.001	0.006	0.020	-0.048	0.005	-0.004	
GEP	0.024	0.059	0.000	-0.002	-0.004	0.019	-0.004	0.007	-0.003

Table B-11

First-order Derivatives of B (BETA) and Γ (GAMMA) for the Specialists Model at Time 2

	BETA	
	GFP	BED
GFP	-0.000	0.000
BED	-0.000	-0.000

				GAMMA			
	POP	CHD	OLD	NAT	EDU	OOD	GEP
GFP	-0.000	0.000	-0.002	0.000	-0.000	-0.000	0.000
BED	-0.000	-0.000	-0.000	0.004	-0.000	-0.000	-0.000

Table B-12

Loadings for Indicators of Exogenous Constructs (Λ_x) and Error Terms of Exogenous Indicators (Θ_δ) and Loadings for Indicators of Endogenous Constructs (Λ_y) and Error Terms of Endogenous Indicators (Θ_ϵ) for the Specialists Model at Time 2

Variables	Λ_x (Lambda sub x)	Θ_δ (Theta sub delta)*
POP	2.532	0.712
CHD	1.087	0.131
OLD	2.952	0.968
NAT	5.550	5.436
EDU	4.382	3.387
OOD	9.508	10.039
GEP	138.423	3380.264
	Λ_y (Lambda sub y)	Θ_ϵ (Theta sub epsilon)*
SPP	34.556	298.733
BED	54.912	753.969

* Error variances are fixed.
Note: The loadings are standardized.

Table B-13

Covariance Matrix for the Combined Models at Time 2

	SPP	GFP	IRP	BED	CHD	OLD	NAT	EDU	OOD	GEP
SPP	1626.732									
GFP	307.526	907.957								
IRP	743.991	232.706	1377.190							
BED	486.974	113.310	244.788	4009.573						
CHD	-14.801	-8.436	-4.640	-0.077	1.092					
OLD	-2.592	10.616	-13.149	16.298	-1.378	8.446				
NAT	-18.307	22.208	-8.626	-10.588	0.714	-1.040	7.662			
EDU	120.473	27.085	50.601	-13.200	-0.987	-2.132	0.078	25.188		
OOD	-218.725	-8.266	-78.820	-209.233	1.870	6.128	1.830	-12.919	98.604	
GEP	-1235.274	634.989	-452.209	-46.814	42.280	-133.227	170.246	-117.379	192.006	21768.173

Appendix Table B-14

Residuals, $S-\Sigma$ for the Combined Model of Figure 6.4-4 and the Data of Table B-13

	SPP	GFP	IRP	BED	CHD	OLD	NAT	EDU	OOD	GEP
SPP	-0.013									
GFP	-0.041	-0.067								
IRP	-0.018	-0.051	-0.013							
BED	-0.173	-0.328	-0.321	-0.008						
CHD	-0.003	0.052	-0.112	0.021	0.005					
OLD	-0.069	0.475	-1.131	-0.004	0.038	-0.000				
NAT	-0.091	-0.169	-0.209	-1.139	0.030	0.001	0.002			
EDU	-0.024	-0.021	-0.130	-0.568	0.024	0.038	0.001	-0.002		
OOD	-0.017	0.082	-0.223	-0.015	0.011	-0.001	-0.090	-0.037	-0.001	
GEP	0.156	0.111	0.189	0.010	0.003	-0.023	0.032	-0.022	0.011	-0.006

Table B-15

First-order Derivatives of B (Beta) and Γ (Gamma) for the Combined Model (Including Interns and Residents) at Time 2

	BETA				GAMMA					
	SPP	GFP	IRP	BED	CHD	OLD	NAT	EDU	OOD	GEP
SPP	-0.000	0.000	-0.000	-0.000	-0.000	0.001	0.000	-0.000	0.000	-0.088
GFP	0.000	-0.000	0.000	-0.036	-0.000	-0.006	-0.000	0.000	-0.006	-0.000
IRP	-0.000	0.000	0.000	0.036	0.000	0.007	0.001	-0.000	0.006	-0.082
BED	0.011	0.021	0.005	0.000	-0.000	-0.000	0.004	0.004	-0.000	0.000

Table B-16

Loadings for Indicators of Exogenous Constructs (Λ_x) and Error Terms of Exogenous Indicators (Θ_δ) and Loadings for Indicators of Endogenous Constructs (Λ_y) and Error Terms of Endogenous Indicators (Θ_ϵ) for the Combined Model (Including Interns and Residents) at Time 2

Variables	Λ_x (Lambda sub x)	Θ_δ (Theta sub delta)*
CHD	0.991	0.109
OLD	2.757	0.845
NAT	2.552	1.149
EDU	4.628	3.778
OOD	9.421	9.860
GEP	136.076	3265.226

	Λ_y (Lambda sub y)	Θ_ϵ (Theta sub epsilon)*
IRP	36.108	325.346
GFP	27.080	181.591
SPP	33.223	275.438
BED	56.669	801.915

* Error variances are fixed.
Note: The loadings are standardized.

Table B-17

Residuals, S-Σ for the Combined Model (Excluding Interns and Residents) of Figure 6.4-5 and the Data of Table B-13

	SPP	GFP	BED	CHD	OLD	NAT	EDU	OOD	GEP
SPP	-0.014								
GFP	-0.042	-0.067							
BED	-0.156	-0.312	0.019						
CHD	0.015	0.057	0.024	0.003					
OLD	0.102	0.495	0.066	0.024	0.000				
NAT	-0.071	-0.138	-1.112	0.032	0.020	0.001			
EDU	-0.020	-0.030	-0.611	0.021	0.014	-0.001	-0.003		
OOD	0.004	0.052	-0.003	0.006	-0.000	-0.081	-0.043	-0.001	
GEP	0.076	0.052	0.045	-0.000	-0.017	0.028	-0.002	0.009	-0.005

Table B-18

First-order Derivatives of B (Beta) and Γ (Gamma) for the Combined Model (Excluding Interns and Residents) at Time 2

	BETA			GAMMA					
	SPP	GFP	BED	CHD	OLD	NAT	EDU	OOD	GEP
SPP	-0.000	-0.000	-0.000	0.000	0.000	-0.000	-0.000	0.000	-0.041
GFP	0.000	-0.000	-0.024	0.000	-0.004	0.000	0.000	-0.003	0.000
BED	0.012	0.020	-0.000	0.000	0.000	0.004	0.004	0.000	0.000

Table B-19

Loadings for Indicators of Exogenous Constructs (Λ_x) and Error Terms of Exogenous Indicators (Θ_δ) and Loadings for Indicators of Endogenous Constructs (Λ_y) and Error Terms of Endogenous Indicators (Θ_ϵ) for the Combined Model (Excluding Interns and Residents) at Time 2

Variables	Λ_x (Lambda sub x)	Θ_δ (Theta sub delta)*
CHD	0.991	0.109
OLD	2.757	0.845
NAT	2.552	1.149
EDU	4.628	3.778
OOD	9.421	9.860
GEP	136.066	3265.226
	Λ_y (Lambda sub y)	Θ_ϵ (Theta sub epsilon)*
SPP	36.110	325.346
GFP	27.078	181.591
BED	56.562	801.915

* Error variances are fixed.
Note: The loadings are standardized.

APPENDIX C: COVARIANCE MATRICES AND MEASUREMENT MODEL PARAMETERS FOR MODELS OF CHANGE

Table C-1

Covariance Matrix for the Models of Change in Physician Distribution (N=189)

	ΔSPP	ΔGFP	ΔBED	ΔPOP	ΔCHD	ΔOLD	ΔNAT	ΔEDU	ΔOOD
ΔSPP	1493.664								
ΔGFP	294.064	806.418							
ΔBED	433.377	117.635	3769.843						
ΔPOP	-14.181	8.078	5.542	7.124					
ΔCHD	-	-7.876	1.896	-0.746	1.313				
ΔOLD	-5.577	8.427	10.112	-0.759	-1.892				
ΔNAT	-35.716	15.944	23.797	-1.028	2.803	-2.635	36.238		
ΔEDU	106.083	25.369	-8.285	5.438	-0.848	-2.297	-0.828	22.582	
ΔOOD	-215.675	-20.012	-195.814	-12.032	1.321	7.619	-0.616	-13.574	100.394

Table C-2

Residuals, S-Σ for the Model of Change in General (Family) Practitioners and the Data of Table C-1

	ΔGFP	ΔBED	ΔPOP	ΔCHD	ΔOLD	ΔNAT	ΔEDU	ΔOOD
ΔGFP	-0.004							
ΔBED	-0.037	0.000						
ΔPOP	-0.278	0.010	0.000					
ΔCHD	-0.007	0.009	-0.016	-0.001				
ΔOLD	-0.000	0.004	-0.005	-0.001	-0.000			
ΔNAT	-0.011	-0.113	0.014	0.004	0.005	-0.000		
ΔEDU	0.021	0.001	0.007	0.002	0.000	-0.002	-0.001	
ΔOOD	-0.019	-0.001	-0.004	-0.000	0.000	-0.007	0.000	0.000

Table C-3

First-order Derivatives of B (Beta) and Γ (Gamma) for the Model of Change in General (Family) Practitioners

	BETA	
	ΔGFP	ΔBED
ΔGFP	-0.000	0.000
ΔBED	0.002	0.000

			GAMMA			
	ΔPOP	ΔCHD	ΔOLD	ΔNAT	ΔEDU	ΔOOD
ΔGFP	0.002	0.000	0.000	0.000	-0.000	-0.000
ΔBED	0.000	0.000	0.000	0.001	-0.000	-0.000

Table C-4

Loadings for Indicators of Exogenous Constructs (Λ_x) and Error Terms of Exogenous Indicators (Θ_δ) and Loadings for Indicators of Endogenous Constructs (Λ_y) and Error Terms of Endogenous Indicators (Θ_ϵ) for the Model of Change in General (Family) Practitioners

Variables	Λ_x (Lambda sub x)	Θ_δ (Theta sub delta)*
ΔPOP	2.532	0.712
ΔCHD	1.087	0.131
ΔOLD	2.952	0.968
ΔNAT	5.550	5.436
ΔEDU	4.381	3.387
ΔOOD	9.505	10.039
	Λ_y (Lambda sub y)	Θ_ϵ (Theta sub epsilon)*
ΔGFP	25.407	161.284
ΔBED	54.916	753.969

* Error variances are fixed

Note: The loadings are standardized

Table C-5

Residuals, S-Σ for the Model of Change in Specialists and the Data of Table C-1

	ΔSPP	ΔBED	ΔPOP	ΔCHD	ΔOLD	ΔNAT	ΔEDU	ΔOOD
ΔSPP	0.001							
ΔBED	-0.010	0.001						
ΔPOP	0.002	0.001	-0.000					
ΔCHD	0.030	0.007	-0.000	0.001				
ΔOLD	0.196	-0.007	-0.003	0.007	-0.000			
ΔNAT	-0.019	-0.110	-0.001	0.004	0.011	-0.001		
ΔEDU	0.008	0.004	-0.000	-0.005	-0.037	0.001	-0.003	
ΔOOD	-0.013	-0.003	0.000	0.003	0.018	-0.009	0.004	-0.002

Table C-6

First-order Derivatives of B (Beta) and Γ (Gamma) for the Model of Change in Specialists

	BETA		GAMMA					
	ΔSPP	ΔBED	ΔPOP	ΔCHD	ΔOLD	ΔNAT	ΔEDU	ΔOOD
ΔSPP	0.000	-0.000	-0.000	-0.000	-0.002	0.000	-0.000	-0.000
ΔBED	0.002	-0.000	-0.000	-0.000	-0.000	0.001	-0.000	-0.000

Table C-7

Loadings for Indicators of Exogenous Constructs (Λ_x) and Error Terms of Exogenous Indicators (Θ_δ) and Loadings for Indicators of Endogenous Constructs (Λ_y) and Error Terms of Endogenous Indicators (Θ_ϵ) for the Model of Change in Specialists

Variables	Λ_x (Lambda sub x)	Θ_δ (Theta sub delta)*
ΔPOP	2.532	0.712
ΔCHD	1.087	0.131
ΔOLD	2.952	0.968
ΔNAT	5.550	5.436
ΔEDU	4.382	3.387
ΔOOD	9.507	10.039
	Λ_y (Lambda sub y)	Θ_ϵ (Theta sub epsilon)*
ΔSPP	34.566	298.733
ΔBED	54.912	753.969

* Error variances are fixed.
Note: The loadings are standardized.

Table C-8

Residuals, S-Σ for the Model of Change in Physicians and the Data of Table C-1

	ΔSPP	ΔGFP	ΔBED	ΔCHD	ΔOLD	ΔNAT	ΔEDU	ΔOOD
ΔSPP	-0.045							
ΔGFP	-0.092	-0.013						
ΔBED	-0.319	-0.064	-0.002					
ΔCHD	0.085	-0.097	-0.019	0.002				
ΔOLD	0.036	-0.486	-0.020	-0.014	0.002			
ΔNAT	-0.931	0.097	-0.158	-0.032	0.032	-0.002		
ΔEDU	-0.036	-0.072	-0.780	0.016	0.039	0.175	-0.001	
ΔOOD	0.002	0.413	-0.026	0.026	0.007	-0.129	-0.055	-0.004

Table C-9

First-order Derivatives of B (Beta) and Γ (Gamma) for the Model of Change in Physicians

	BETA			GAMMA				
	ΔSPP	ΔGFP	ΔBED	ΔCHD	ΔOLD	ΔNAT	ΔEDU	ΔOOD
ΔSPP	-0.000	-0.000	0.000	-0.000	-0.000	0.022	0.000	0.000
ΔGFP	-0.000	-0.000	0.000	0.000	0.003	-0.000	-0.000	-0.010
ΔBED	0.017	-0.006	-0.000	-0.000	-0.000	0.001	0.004	0.000

Table C-10

Loadings for Indicators of Exogenous Constructs (Λ_x) and Error Terms of Exogenous Indicators (Θ_δ) and Loadings for Indicators of Endogenous Constructs (Λ_y) and Error Terms of Endogenous Indicators (Θ_ϵ) for the Model of Change in Physicians

Variables	Λ_x (Lambda sub x)	Θ_δ (Theta sub delta)*
ΔCHD	1.087	0.131
ΔOLD	2.951	0.968
ΔNAT	5.551	5.436
ΔEDU	4.381	3.387
ΔOOD	9.508	10.039
	Λ_y (Lambda sub y)	Θ_ϵ (Theta sub epsilon)*
ΔSPP	34.669	298.733
ΔGFP	25.421	161.284
ΔBED	54.924	753.969

* Error variances are fixed.
Note: The loadings are standardized.

Appendix D

Physician Distribution: An Analysis Employing Provincial Dummy Variables

The relation between the nine provincial variables and other characteristics of census divisions and physician ratios for 1971 and 1981 are exhibited in Table D1 in terms of zero-order correlations. The correlations do not come close to our claim stated in the text that provincial variations in methods of organizing, financing, and administering of health insurance plans explain disparity in physician/population ratios at the census division level. However, two patterns in Table D1 are noteworthy.

The first is the relation between the provinces Quebec and British Columbia and the general(family) practitioner ratios for 1981. Quebec and British Columbia differ significantly from Ontario, the reference category, with regard to general(family) practitioner ratio (r=-0.238 and 0.427 respectively).

Second, is the different sign of the correlations. For example, Quebec and British Columbia relative to Ontario had lower ratios of general practitioners and family physicians in 1971 (r=-0.168 and -0.002 abcdsfghhjkllfor Quebec and British respectively for Quebec and British Columbia). But by 1981, British Columbia (relative to Ontario) had higher general practitioners and family physician ratios while Quebec continued to have lower ratios (r=-0.238 and r=0.427 respectively for Quebec and British Columbia). These correlations are important. By their strength they reveal the importance of provincial policies for variation in ratios of physicians. Analysis of physician distribution using census divisions as units of analyses would overlook the effects of such provincial policies.

To ascertain the relative influence of these provincial variables on physician ratios - once the effects of other factors are controlled - multiple regression analyses were conducted. Tables D2 and D3 show the results of the regression analyses. The comparisons of regression coefficients are particularly important because they indicate whether the independent variables - provinces - have differential influence on different types of physicians. The presentation of the results proceeds in terms of a discussion of coefficients for each of the provincial variables.

Areas in Alberta relative to areas in Ontario typically have smaller intern and resident ratios in 1971 (Table D2). Similarly, areas in Quebec had relatively smaller general(family) practitioner and specialist ratios. Province to which a census division belongs is important in understanding physician distribution, however, it is substantially less important than socio-demographic and environmental attributes of an area. The regression results for 1971 are in basic agreement with the fact that Quebec used hospital least (see our discussion in section 2.3.2). Insofar as this factor is typically associated with physician supply, physician/population ratios were lower in Quebec than in most other provinces a decade ago.

Table D3 reports the results of regressions of 1981 data. The situation had changed by 1981. Provinces were responding in a less consistent fashion to physician/population ratios in the more recent period. The findings of central interest in the present context are (a) the significant positive effects of Newfoundland on all the three types of physician ratios, (b) significant positive effects of British Columbia on general practitioners and family physicians ratio, and (c) significant negative effects of Alberta on specialists.

The conclusions derived from Tables D2 and D3 are less clear and inconsistent regarding the relations between provincial variables and physician ratios (especially specialist ratios). In all of the 1971 equations, the parameter estimates for provincial variables (of course, with the exception of Quebec) are quite small and not statistically significant. In the 1981 equations, however, the estimates are somewhat larger, but only the coefficient for Newfoundland is highly significant. Even here, when we compare the specialists equation with those where provincial variables are omitted, the pattern of significance, the size of coefficients, and the amount of variance explained are quite similar. These findings reinforce earlier conclusions that when demographic, socio-economic, and environmental factors are taken into account, provinces are coming to have a smaller effect on physician/population ratios. Of course, in the more recent period provinces may have come to exercise an effect on physician supply through variables such as physician income not included in the model. Still, the combination of variables included in the model applied to the three physician types suggests that provinces have come to play between 1971 and 1981 a less direct role in influencing physician distribution, at the census division level.

The fact that Medicare has served to maintain more inter-regional equality in physician incomes than population utilization of physician services (Barer and Evans, 1986) also indicates that provincial variations in health care system by themselves probably do not contribute to greater variations in physician/population ratios. Thus, at this point, it seems reasonable to conclude that organizing, financing, and administrating of health care services do not greatly affect physician/population ratios at least at the census division level, although they may affect inter-provincial dispersion in medical care use. However, the relatively large increase in variance explained (in the case of interns and residents, and general(family) practitioners) when provincial variables are included provide some support for the importance of provincial variables in explaining the two types of physicians - interns and residents, and general(family) practitioners. The theoretical and methodological justifications of the omission outlined earlier, lends confidence in the specification of the model, especially in terms of the relevance of the set of variables (socio-demographic) that are retained as determinants of physician/population ratios.

Table D1

Correlation Coefficients of Physician/Population Ratios and Demographic, Socio-economic, Environmental and Provincial Variables, Canadian Census Divisions, 1971-1981

		1971	
	IRP	GFP	SPP
POP	0.686**	0.647**	0.693**
CHD	-0.125	-0.110	-0.130
OLD	-0.001	0.044	0.013
NAT	-0.102	-0.056	-0.110
EDU	0.338*	0.234	0.336*
OOD	-0.302	-0.149	-0.304
GEP	-0.055	-0.070	-0.065
BED	0.074	0.010	0.061
NFld.	0.007	-0.015	-0.015
P.E.I.	-0.040	0.000	-0.013
N.S.	0.043	-0.003	0.024
N.B.	-0.059	-0.063	-0.021
Que.	-0.149	-0.168	-0.147
Man.	0.008	-0.037	-0.009
Sask.	-0.061	-0.008	-0.079
Alta.	0.006	-0.017	0.009
B.C.	-0.048	-0.002	-0.010
		1981	
POP	0.205*	0.087	0.473**
CHD	-0.120	-0.247**	-0.351**
OLD	-0.122	0.108	-0.022
NAT	-0.084	0.276**	-0.164
EDU	0.272**	0.181	0.595**
OOD	-0.214*	-0.042	-0.546**
GEP	-0.083	0.163	-0.208*
BED	0.104	0.064	0.191*
NFld.	0.401**	0.086	0.029
P.E.I.	-0.048	0.050	0.007
N.S.	-0.008	0.027	0.055
N.B.	-0.076	-0.156	0.010
Que.	0.001	-0.238*	-0.086
Man.	-0.036	0.044	-0.042
Sask.	-0.029	0.055	-0.057
Alta.	-0.055	-0.026	-0.075
B.C.	-0.078	0.427**	0.030

Table D-2

Results of Multiple Regression Analysis, Physician Distribution, Canadian Census Divisions, 1971

	IRP		GFP		SPP	
	B	Beta	B	Beta	B	Beta
POP	19.400	0.904**	29.379	0.998	28.234	0.776**
CHD	-11.062	-0.108	-12.483	-0.089	-9.228	-0.144
OLD	-8.813	-0.348**	-13.541	-0.390**	-9.486	-0.311**
NAT	-1.116	-0.028	-4.244	-0.078	0.129	0.005
EDU	-3.084	-0.108	-9.167	-0.234	-1.750	-0.051
OOD	0.389	0.046	2.057	0.176	0.573	0.062
GEP	-0.192	-0.297**	-0.286	-0.324	-0.097	-0.169**
BED	0.011	0.005	-0.100	-0.037	0.136	0.061
Nfld.	-22.728	-0.033	-74.457	-0.078	-1.192	-0.003
P.E.I.	33.109	0.047	98.559	0.103	29.125	0.040
N.S.	-6.584	-0.009	-21.815	-0.023	21.360	0.065
N.B.	3.448	0.011	10.542	0.024	5.025	0.014
Que.	-48.266	-0.259	-74.733	-0.293*	-36.974	-0.179**
Man.	-5.190	-0.010	-42.710	-0.063	7.177	0.018
Sask.	11.518	0.041	40.393	0.106	8.333	0.022
Alta.	-80.293	-0.161*	-103.611	-0.152	-20.804	-0.058
B.C.	-41.845	-0.102	-12.221	-0.022	10.894	0.027
R^2(adj.)		0.493	0.490		0.519	
Standard Error		64.698	88.871		64.254	
F		4.323	4.275		12.630	

Note: Listwise deletion of missing data was employed as the option

* Coefficient at least 1.5 times its standard error
** Coefficient at least twice its standard error

B = Partial Regression Coefficient
Beta = Standardized Regression Coefficient

Table D-3

Results of Multiple Regression Analysis, Physician Distribution, Canadian Census Divisions, 1981

	IRP		GFP		SPP	
	B	Beta	B	Beta	B	Beta
POP	0.120	0.009	-1.163	-0.107	1.397	0.096*
CHD	-5.601	-0.163*	-8.193	-0.283**	-3.174	-0.094
OLD	-0.502	-0.041	1.030	0.100	1.436	0.116
NAT	0.673	0.051	2.970	0.264**	-0.196	-0.031
EDU	2.175	0.300**	1.107	0.180*	4.023	0.495**
OOD	-0.411	-0.113	-0.109	-0.035	-1.469	-0.381**
GEP	-0.005	-0.022	-0.006	-0.028	-0.008	-0.029
BED	0.035	0.060	0.035	0.071	0.043	0.068
Nfld.	87.108	0.410**	32.443	0.180**	31.414	0.143**
P.E.I.	-17.428	-0.052	15.189	0.054	-9.195	-0.030
N.S.	-0.068	0.000	1.982	0.015	6.683	0.048
N.B.	-5.795	-0.041	-13.608	-0.115*	2.111	0.014
Que.	12.341	0.162*	4.408	0.068	10.048	0.120*
Man.	8.364	0.055	5.990	0.046	6.385	0.037
Sask.	0.992	0.007	1.174	0.009	-7.248	-0.049
Alta.	-1.996	-0.014	4.195	0.035	-16.202	-0.106*
B.C.	-12.246	-0.080	50.451	0.390**	3.621	0.021
R^2(adj.)		0.212	0.294		0.562	
Standard Error		32.217	25.837		25.573	
F		3.631	5.061		15.200	

Note: Listwise deletion of missing data was employed as the option

* Coefficient at least 1.5 times its standard error
** Coefficient at least twice its standard error

B = Partial Regression Coefficient
Beta = Standardized Regression Coefficient